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CH-47A, B AND C SERIES HELICOPTER ROTOR BLADE FAILURE AND SCRAP RATE DATA ANALYSIS

By

R. L. Hunt

November 1971

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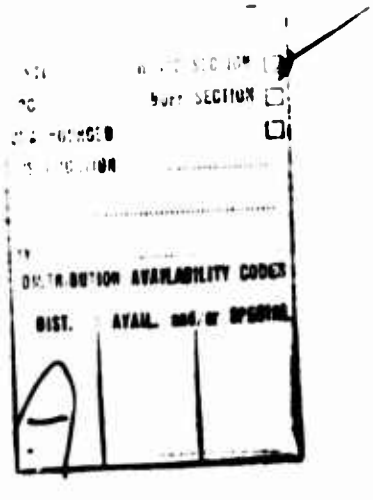

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13. ABSTRACT

This report provides the results of an analysis of failure data derived from depot inspection, overhaul/rework, and scrappage reports on 5,488 rotor blades of the CH-47 series tandem rotor helicopters. Two types of rotor blades were analyzed for blade mean-time-between-removals, mean-time-to-removals, mean-time-between-unscheduled-removals and mean-time-between-scrappage. Locations on these blades for the major discrepancies were determined. Blade teardown experience was determined. A cost comparison of blade acquisition costs versus the average cost of repair/rework was provided.

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DEPARTMENT OF THE ARMY
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The Eustis Directorate of the U.S. Army Air Mobility Research and Development Laboratory is conducting a series of design studies and hardware evaluations leading to improved reliability and maintainability (R&M) characteristics for future helicopter rotor blades. It is intended that design requirements will be tailored to each aircraft type (utility, attack, transport, etc.) with full consideration of operational environment impacts (combat damage, foreign object damage, etc.) included.

This contract was awarded to analyze the operational R&M history of CH-47A, B, and C model helicopter rotor blades to establish design considerations for transport type aircraft. The findings presented herein are considered to be most accurate and directly usable in establishing expected rotor blade external damage rates for the type of helicopter in question. Results of this analysis will be used for evaluation of advanced rotor blade design concepts currently being investigated under this Directorate's R&M research and development program. This report is published as a parallel to the USAAVLABS Technical Report 71-9, "UH-1 and AH-1 Helicopter Main Rotor Blade Failure and Scrap Rate Data Analysis", which presented data for consideration in the design of utility and attack helicopter rotor blades.

The technical monitor for this contract was Major Vincent G. Ripoll, Reliability and Maintainability Division, Eustis Directorate.

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CH-47A, B AND C SERIES HELICOPTER ROTOR BLADE FAILURE AND SCRAP RATE DATA ANALYSIS

Final Report

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Prepared By
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for

EUSTIS DIRECTORATE
U.S. ARMY AIR MOBILITY RESEARCH AND DEVELOPMENT LABORATORY
FORT EUSTIS, VIRGINIA

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SUMMARY

This report has the purpose of providing the results of an analysis of failure data derived from depot inspection, overhaul/rework, and scrappage of 5,488 rotor blades of the CH-47 series tandem rotor helicopters. These blades were returned after RVN and CONUS operations over a time period from July 1, 1962 through March 1, 1971, with an accumulation of 2,521,734 actual blade operating hours with an equivalent accumulation of 5,679,399 operating hours for all blades in the helicopter fleet.

Analyses of unscheduled removals, repair, overhaul, and scrap data were conducted on two different types of blades. Compilation of total quantity of blades investigated has been provided, as well as accumulated time on all blades at removal.

Analyses to determine the blade design parameters as mean-time-between-removals (MTBR), mean-time-to-removals (MTTR) and mean-time-between-unscheduled-removals (MTBUR) have been included. Results may be compared for changes in these parameters in preceding from the early to the later model. Changes in these parameters can be attributed to incorporation of engineering changes, evolution of improved manufacturing, shipping, handling and modified maintenance practices.

Analyses to determine reasons for removals, repairs and scrappage as a percentage of total blades removed and of total blades scrapped have been compiled. Reported reasons for removal are consistent with reasons for repair and for scrappage. Blades subjected at the manufacturer's repair facility to close detailed inspection, disassembly, or repair for minor damage sometimes indicated serious defects as extensive water migration, exterior spar corrosion and similarly hidden damages. Additional reasons for scrappage were, therefore, discovered. A very minor quantity of blades may be scrapped due to in-transit depot handling and processing damages. Analysis results for the mean-time-between-scrappage (MTBS) for both CH-47A and B/C blades have been included.

Conclusions of this analysis indicate that the later CH-47B/C blades have been designed to decrease the amount of inherent discrepancies. However, they are more susceptible to externally caused discrepancies than the CH-47A helicopter blades. It is recommended that field repair and blade handling procedures be reviewed for modifications in line with the results of this report.

FOREWORD

This report provides an analysis of rotor blade failure and scrap rate historical data as reported on the tandem rotor helicopters, CH-47A, CH-47B and CH-47C. This analysis was conducted under Contract DAAJ02-71-C-0014 (Task 1F162205A11901) for the Eustis Directorate, U. S. Army Air Mobility Research and Development Laboratory (USAAMRDL), Fort Eustis, Virginia.

USAAMRDL technical direction was provided by Major Vincent G. Ripoll.

The principal analyst for The Boeing Company, Vertol Division, was Mr. R. L. Hunt, assisted by Mr. E. C. Daley and Mr. J. J. Chmura, all of M&R Engineering. Program management and technical direction were provided by Mr. H. J. Smith, Sr., Product Support Engineer, Mr. R. E. Spears, Sr., Product Support Engineer, Mr. R. Hazlett, Manager Product Assurance R&D, and Mr. P. W. Fiedler, Unit Chief Reliability and Maintainability.

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INTRODUCTION

Helicopter rotor blade failure and scrap rate information as reported during depot rework is an important source of blade data. This data may be used analytically to determine removal rates and mean removal values, to determine blade scrappage rates and mean scrappage values and enable correlation of these rates and values with the various reasons for blade removal from the helicopter and for subsequent repair or scrappage.

The above data was available, as The Boeing Company, Vertol Division has been repairing and updating CH-47 helicopter rotor blades under a U. S. Army contract since the incorporation of this helicopter into the Army inventory in 1962.

During the time from 1962 through 1970, the Vertol Division has been the sole contractor for depot rework of CH-47 helicopter rotor blades. From all data generated from the rework facility and from field activities, a data system was developed to record utilization, discrepancies, failure modes, configuration control, and reason for blade removal/scrappage. This data has been maintained in a usable format to enable blade analyses to be readily accomplished at any time.

This data has been continually extracted, reviewed and verified by Boeing Company/Vertol Division personnel who possessed specialized backgrounds in the fields of reliability, maintainability, service engineering, design, military/aviation, data analysis and military/civilian overhaul/repair facilities. It is from the above data source that this CH-47A, B and C series helicopter rotor blade failure data and scrap rate data analysis has been compiled.

SCOPE

The objective of this effort was to conduct an analysis of available CH-47A, B and C series helicopter rotor blade failure and scrap rate data to determine unscheduled and scheduled removal rates, to develop mean-time-between-removal values, to determine blade scrappage rates, and to correlate these rates and values with the various reasons for removal and scrappage.

This data was derived entirely from depot level repair and scrappage reports on two types of rotor blades used on three different helicopter models as shown by Table I below.

TABLE I. ANALYZED ROTOR BLADES IDENTIFICATION

APPLICABLE HELICOPTER	HELICOPTER SERIAL NUMBERS	APPLICABLE ROTOR BLADES PART NUMBERS
CH-47A	59-4982 & Subsequent	P/N 114R1002
CH-47B	66-19098 & Subsequent	P/N 114R1502
CH-47C	67-18494 & Subsequent	P/N 114R1502

The CH-47A type of rotor blade with a steel spar, fiberglass skins, and aluminum ribs is constructed as a symmetrical airfoil. The CH-47B/C type of rotor blade, with a steel spar, fiberglass skins, honeycomb fillers and plastic end ribs is constructed as a nonsymmetrical airfoil. Due to these major design differences, the analytical effort, therefore, treated these two types of blades independently. A detailed discussion of blade differences and how these were treated in the analyses is given under analysis approach, page 3.

ANALYSIS APPROACH

This section describes the preliminary steps taken prior to accomplishment of the analytical efforts concerned with blade removals and blade scrappage.

The two types of blade configurations, i.e., CH-47A symmetrical type and the CH-47B/C nonsymmetrical type, and their different installation locations, i.e., forward and aft rotors, have had a bearing upon the extent of data available for extraction; therefore, these blade configurations and installations are described in detail herein.

The organization of the data into a form suitable for extraction of material useful for the analyses contained in this report required the application of a specific data extraction process which is discussed below.

Certain data limitations exist for the data reporting time period investigated. One limitation concerns the fact that all blade repairs, overhaul, and scrappage have been accomplished at the depot level. Thus data reporting on blade repairs and scrappage occurred at this level for a total of 2,521,734 actual blade hours. During this same interval, if field level (organizational through general support maintenance levels) data had been available, a total of 5,679,399 blade operating hours could have been used as the analysis data base. A second limitation is the possible loss of data due to unusual incidents. A third limitation is the possible dilution of the blade population by excessive categorization. These limitations are discussed herein.

Identification of reasons for removal, repair, and scrappage required a simplified tabulation of the standard military coding to handle the quantity of data. This tabulation is discussed below. Recognition of the inspection criterion against which blades are removed or scrapped is discussed.

Calculation of blade means representative of blade operating experience requires definition of these means and development of appropriate equations. These steps are presented herein.

DESCRIPTION OF CH-47 HELICOPTER ROTOR SYSTEMS

CH-47A Rotor Systems

The CH-47A helicopter rotor system consists of two rotor installations: one at the forward end of the aircraft and one at the aft end, as shown in Figure 1. These installations are similar but not identical. Each installation includes three interchangeable blade assemblies and a rotor head assembly. The helicopter thus has a total of six blades. These blades are not interchangeable between the two locations. Blade rotation direction is counterclockwise for the forward rotor and clockwise for the aft rotor (in a plan view).

CH-47B/C Rotor Systems

The CH-47B/C rotor system is similar to that of the CH-47A. However, the blades used on these two types of aircraft are different and are not interchangeable between aircraft.

DESCRIPTION OF CH-47 HELICOPTER ROTOR BLADES

CH-47A Rotor Blades

The CH-47A rotor blade assembly as shown in Figure 2 is a symmetrical airfoil shape. It consists of a D-spar, an attaching socket, a nose cap assembly, a trailing-edge strip, twelve boxed fairings, tip balance provisions, and a faired tip cover. This blade assembly is symmetrically constructed about its horizontal centerlines without camber.

The blade D-spar is of steel tubing, circular at the root where it is threaded to receive the attaching socket fitting, for mounting to the rotor head assembly.

The blade leading edge is a formed stainless-steel nose cap with a balance weight assembly bonded into it. The leading-edge assembly is bonded to the forward edge of the D-spar.

Twelve boxed fairings, consisting of fiberglass skins bonded to airfoil-shaped aluminum ribs, are bonded to the aft side of the D-spar. The trailing edge is formed by bonding a blade-long laminated stainless-steel strip into a special slot in the aft edge of the boxed fairings. Movable balance

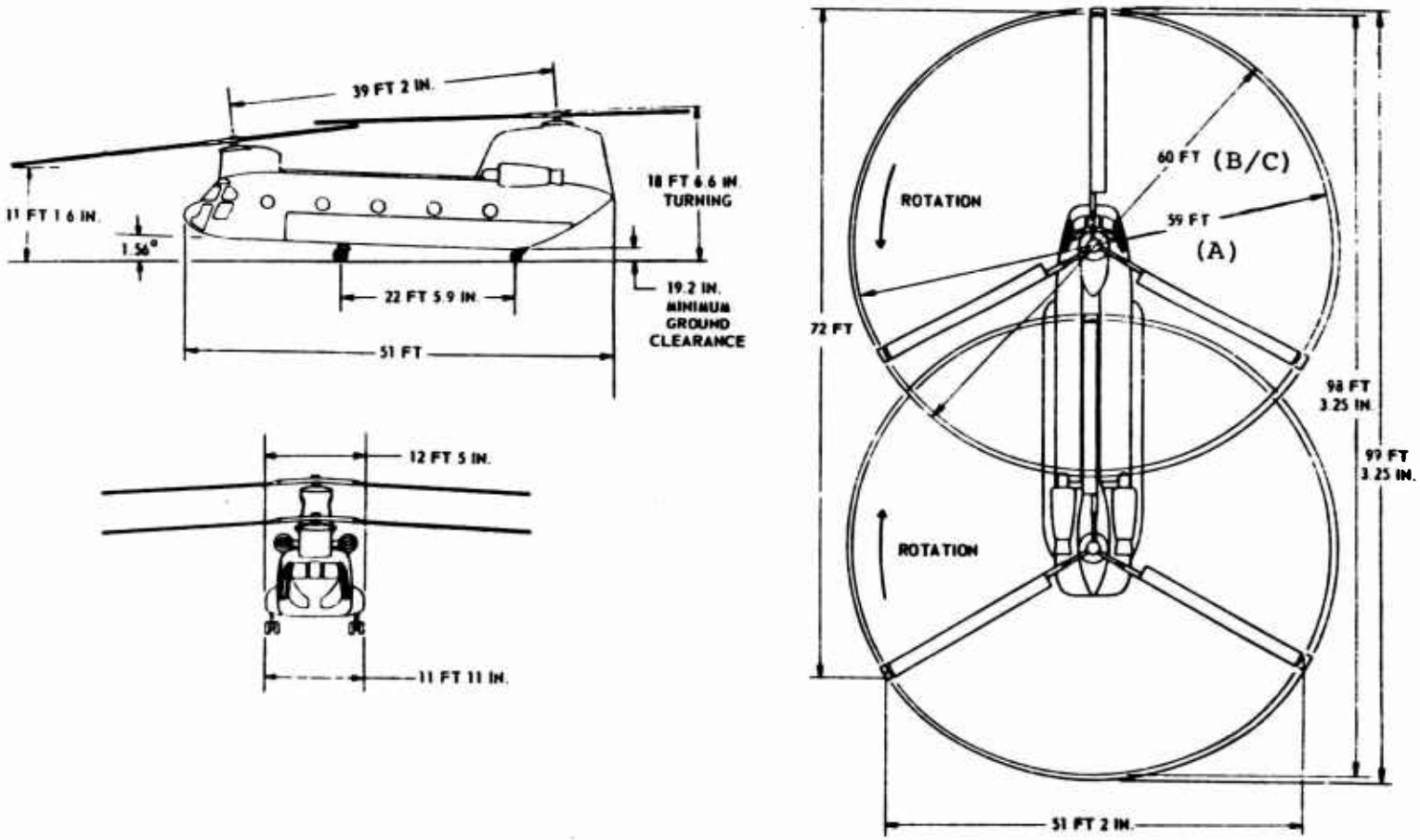


FIGURE 1. CH-47 HELICOPTER ROTOR SYSTEM.

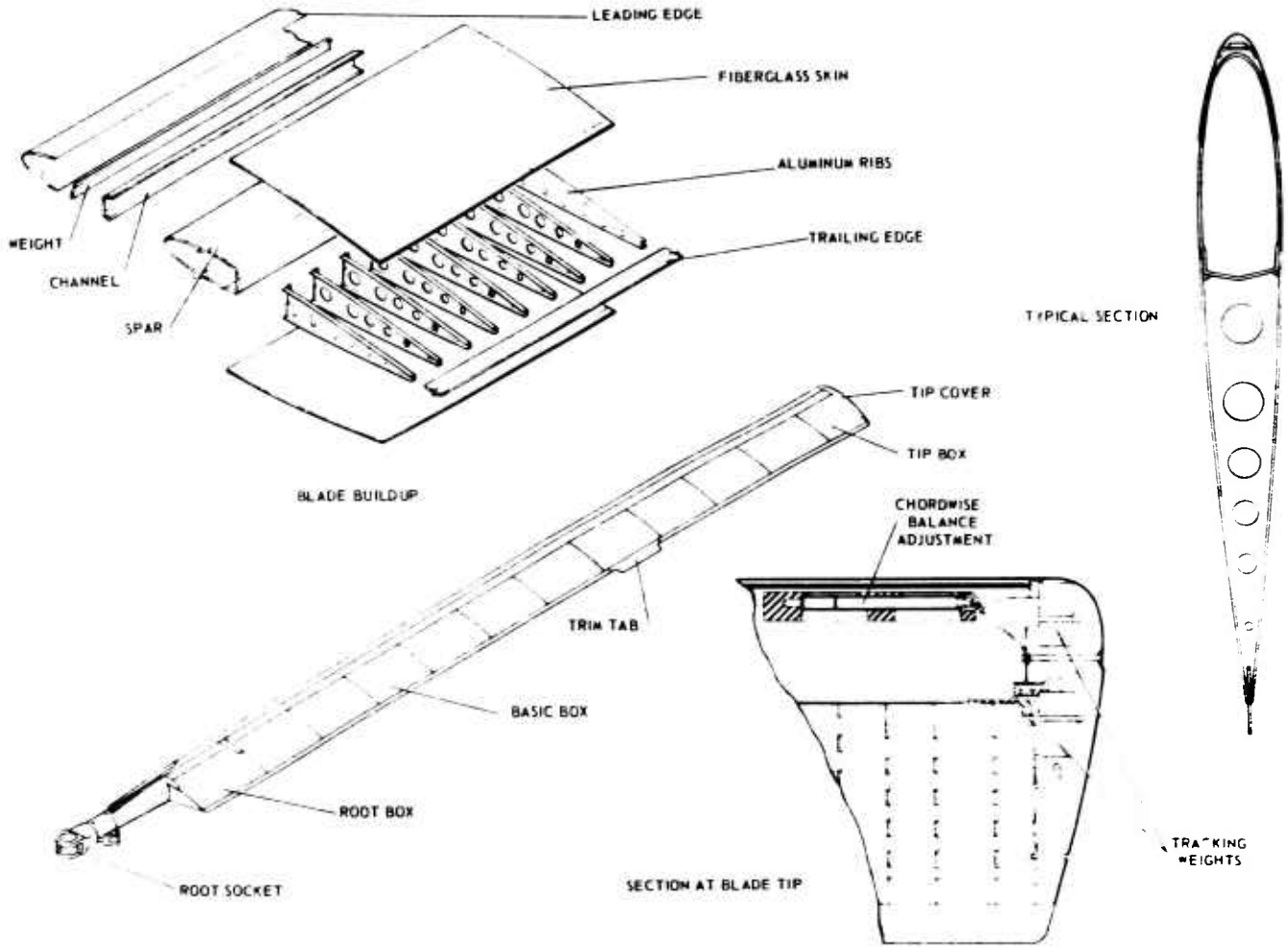


FIGURE 2. CH-47A ROTOR BLADE ASSEMBLY.

and tracking weights are installed on stainless-steel fittings riveted to the tip end of the D-spar. These weights are used to make balance and tracking corrections at the factory. A removable tip cover allows access to these weights. A blade tie-down fitting is located at the blade tip on the bottom surface.

CH-47B/C Rotor Blades

The CH-47B/C rotor blade assembly as shown in Figure 3 is a nonsymmetrical cambered airfoil. The blade assembly consists of a D-spar, an attaching socket, a nose cap assembly, nine boxed fairings, a trailing-edge strip, tip balance provisions and a simplified tip cover. Construction of this blade is similar to the CH-47A blades except for the boxed fairings and nose cap as shown in Figure 3.

DATA EXTRACTION PROCESS

A specific data extraction process was developed and applied to locate, extract, and describe CH-47 rotor blade discrepancies investigated for this report. This was done by the use of an alphanumeric coding system capable of identifying practically all important discrepancies occurring to any part of the entire structure of a CH-47 rotor blade. This alphanumeric system provided different codings for the CH-47A and CH-47B/C blades to allow for blade design differences.

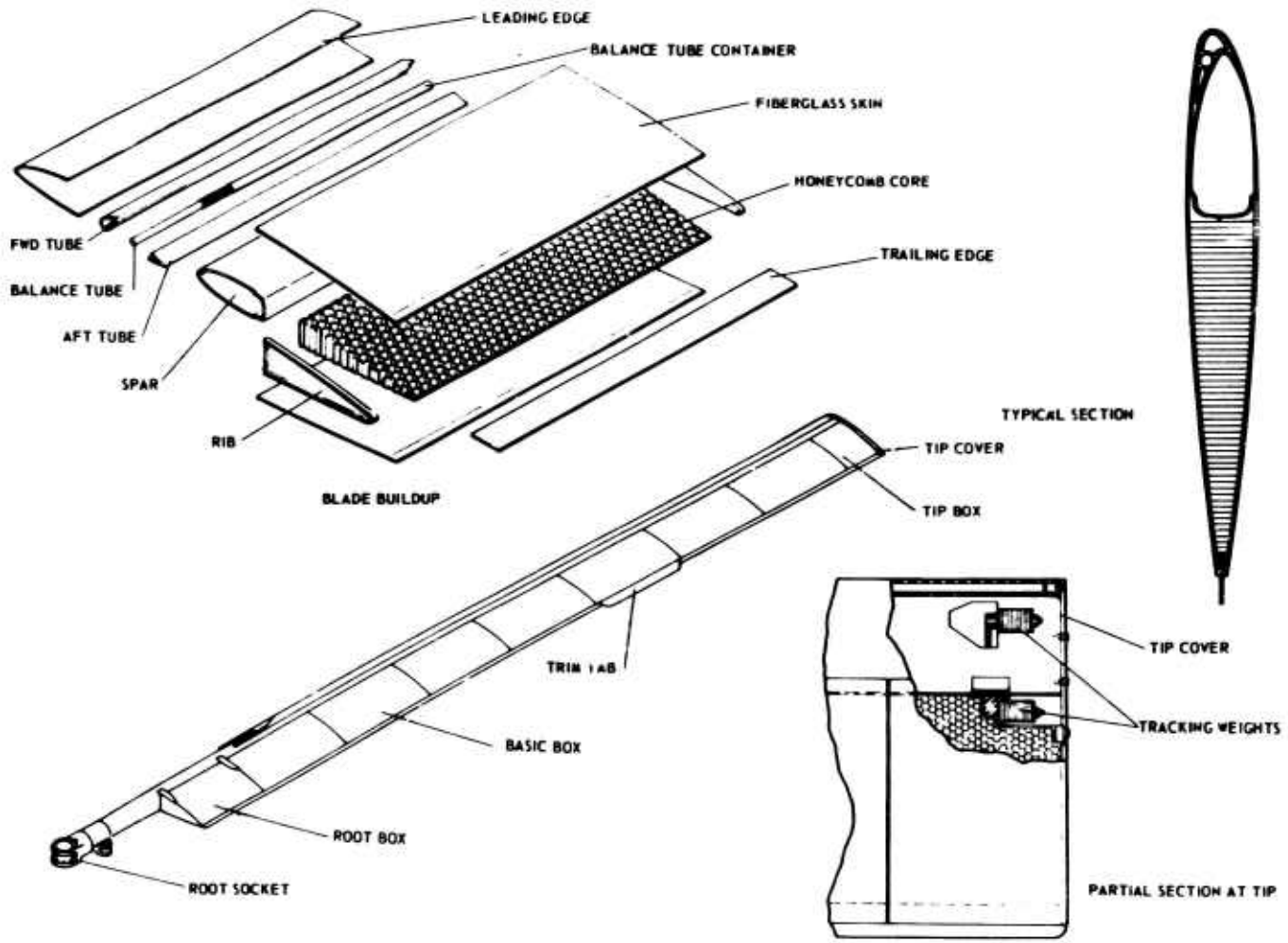


FIGURE 3. CH-47B/C ROTOR BLADE ASSEMBLY.

BLADE REMOVALS ANALYSIS APPROACH

Data Limitations and Use

The data included in this report were compiled from the existing Boeing-Vertol records which have been kept on rotor blades removed elsewhere and shipped to Boeing-Vertol for inspection, repair and scrappage.

The removal dates of interest to this blade removal study are shown in Table II. Note that the time period of interest varies among the CH-47A, B and C model helicopters.

The helicopter flight time accumulated up to the removal dates shown for the CH-47B and CH-47C models have been averaged to provide a consistent basis for the CH-47B/C analysis, as these have not been considered separately.

Loss of Data Due to Unusual Incidents

No data limitations were imposed due to blade damages incurred from unusual field experiences. It could have been decided that blade removal data derived from blade overstress caused by in-air and massive nearby explosions, severe blade flapping due to extreme windstorms, or close helicopter over-flights should have been excluded. However, it was felt that the exclusion of these unusual experiences would provide a distorted view of the complete in-the-field experience; therefore, this data was included.

Examples of two unusual incidents which occurred in RVN and which subjected a large number of CH-47 helicopter blades to severe damage beyond their design limits were:

1. Typhoon Frieda, in November 1967
2. The Camp Evans ammunition dump explosion, in May 1968

Fifty CH-47 rotor blades were involved in the typhoon incident. Of these fifty blades, nine forward and nine aft blades were X-ray diffraction inspected at the depot and were accepted with return to service. Twelve forward and twelve aft blades were X-ray diffraction inspected at the depot, with subsequent rejection for scrappage. The remaining eight blades were severely damaged and were scrapped without further inspection.

TABLE II. BOEING-VERTOL REPAIR/OVERHAUL/SCRAPPAGE INSPECTION RECORDS - DATES AND HELICOPTER FLIGHT HOURS

HELICOPTER	ROTOR LOCATION	BLADE PART NUMBER	REMOVAL DATES FOR BLADE INSPECTION	CORRESPONDING HELICOPTER ACCUMULATED FLIGHT HOURS FOR DATES SHOWN	EQUIVALENT BLADE FLIGHT HOURS
CH-47A	Forward	114R1002	July 1, 1962 thru March 1, 1971	650,206	1,950,618
	Aft	114R1002	July 1, 1962 thru March 1, 1971	650,206	1,950,618
CH-47B	Forward	114R1502	June 1967 thru November 1, 1970	159,419	478,257
	Aft	114R1502	June 1967 thru October 8, 1970	157,914	473,742
CH-47C	Forward	114R1502	April 1968 thru November 1, 1970	138,694	416,082
	Aft	114R1502	April 1968 thru October 8, 1970	136,694	410,082
TOTALS:				1,873,133	5,679,399

Data does not include aircraft flight time incurred in Germany, Korea and Alaska, but does include CONUS and RVN.

The thirty-three CH-47A and sixty-one CH-47B rotor blades that were involved in the Camp Evans explosion were shipped to Boeing-Vertol for inspection and repair, as required.

Blade Population Sizing

During this study, 5,488 blades were reviewed for removal experience. To keep the analysis results at a reasonable level of confidence, this blade population has not been diluted by a large number of categories. It did provide for the separation of all data into forward and aft rotor blade data.

It was felt that the different operational characteristics between these two locations may produce different effects in the externally-caused or inherent discrepancies of these blades. Since blade construction is the same for blades used at both locations, then blade design is eliminated as a possible factor of any differences that resulted from this study.

Determination of Reasons for Removal

Reasons for blade removal, where blades are either repaired or scrapped, have been organized into three major groups based strictly on blade discrepancies. One group concerns inherent blade failures and discrepancies, the second concerns external causes of blade damage or failure, and the third concerns scheduled reasons for blade removal.

The first group essentially includes those discrepancies associated with inadequacy of blade design to withstand actual environmental conditions encountered during field operations. The second group concerns blade failure induced by external influences as foreign object damage, combat, and the like. Included in this group are those blade discrepancies caused by errors due to inadequate shop or field repairs, handling, shipping or maintenance. Also included in this group, for the purpose of records only, are those blades removed without adequate or valid removal reasons. The latter group includes those blades received at the depot and inspected with the result that no damages of the kind reported were found.

This study will be concerned with the unscheduled removal reasons as shown in Table III and the scheduled removal reasons as shown in Table IV.

The Boeing-Vertol repair evaluation reports investigated in the study followed the failure code given by TM-38-750, Reference (1).

It should be noted that where blade damage cause was unknown at the time of removal, this removal analysis included a close review of all recorded discrepancies for these blades to determine what discrepancy would have been the major reason for blade removal for repair.

Appendix II shows the detail and depth to which this removal analysis was conducted. In particular, Figures 29, 30 and 31, as well as the accompanying discussion within this appendix, are of interest.

TABLE III. ROTOR BLADE UNSCHEDULED REASONS FOR REMOVAL/SCRAPPAGE

TYPE OF DISCREPANCY	REASON FOR REMOVAL/ SCRAPPAGE	DESCRIPTORS
Inherent Caused Discrepancy	Deterioration	Missing Bare Steel Eroded Rippled Water Migration
	Unbond	Bulged Blistered Bond Void
	Excessive Vibration	Beyond Tolerance Vibration
	Eroded	Eroded & Other Worn
	Corrosion	Corroded & Other Peeling Chipped Stained Seized Water Migration Pitted
	Delamination	Voided Grazed Cracked Split
	Cracked	Creased Grazed Cracked & Other Split
	Fretted	Worn Fretted
	Imbalance	Tip Rod Loose Imbalance
External Caused Discrepancy	Foreign Object Damage (F.O.D.)	Dented Broken Torn Punctured Scored Bent
	Combat Damage	Broken Scored Dented Punctured Torn Spar/Socket Damage

TABLE III - Continued

TYPE OF DISCREPANCY	REASONS FOR REMOVAL/ SCRAPPAGE	DESCRIPTORS
	Overstress	Overstress & Other Bent Collapse Torn Minor Damage
	Crashes/Strikes	Bent Collapse Torn Minor Damage
Error Caused Discrepancy	Manufacturing/Shipping Maintenance/Repair Shop Error and/Inadequate Field Repair	Human Error
No Valid Removal	No Known or Valid Reason for Removal	No Known Removal Cause
	Unknown/Misc.	Miscellaneous

TABLE IV. ROTOR BLADE SCHEDULED REASONS FOR REMOVAL/SCRAPPAGE

TYPE OF DISCREPANCY	REASON FOR REMOVAL/ SCRAPPAGE	DESCRIPTORS
Time Change	MWO Compliance	MWO
	No defect - Blade Removed for Scheduled Maintenance	Sched. Maint.
	Retired Blade	Retired
Other	EIR Engineering Evaluation	EIR
	No Defect - Blade Removed to Facilitate Maintenance of Other Component(s)	No Defect
	Unknown/Misc.	Miscellaneous

CH-47A, B and C Blade Inspection Requirements

The CH-47 helicopter blade inspection requirements are discussed below. These requirements are noted herein to establish the criterion against which blades have been removed and scrapped.

Field inspection for serviceable CH-47A blades follows the minimum requirements noted in TM 55-1520-209-20-1, Reference (2), and for serviceable CH-47 B/C blades follows the minimum requirements noted in TM 55-1520-227-20-1, Reference (3). When a blade does not satisfy these conditions, it must be repaired or replaced, as applicable. For those blades sent back for depot rework and repair at the manufacturer's facility, the requirements of TM 55-1520-209-35-2 for the CH-47A blades, Reference (4), and of TM 55-1520-227-35-3 for the CH-47B and CH-47C blades, Reference (5), are followed. Partial or full teardown of 20% to 30% of the blades sent to the depot will occur. These teardowns will assure a complete determination of the extent of blade damage or deterioration.

Blade Identification - Overhaul and Retirement Data

Blade identification by dash number, overhaul time (hours), and blade retirement time (hours) for CH-47A rotor blades are shown in Table V.

Blade identification by dash number, blade overhaul time, and blade retirement time in blade hours for CH-47 B/C rotor blades are shown in Table VI.

Data for Table V has been derived from TM 55-1520-209-20-1, Reference (6), and data for Table II from TM 55-1520-227-20-1, Reference (7).

TABLE V. CH-47A BLADE OVERHAUL AND RETIREMENT HOURS DATA

COMPONENT	PART NUMBER	RETIREMENT INTERVAL (BLADE HRS.)
Forward Rotor Blades	114R1002-27	3600
Aft Rotor Blades	114R1002-28 thru -78	2400
	114R1002-80 thru -92	2400

TABLE VI. CH-47B/C BLADE OVERHAUL AND RETIREMENT HOURS DATA

		OVERHAUL INTERVAL (BLADE HRS.)			RETIREMENT INTERVAL (BLADE HRS.)
COMPONENT	PART NUMBER	CH-47B	CH-47C T55-L-7C	CH-47C T55-L-11	
Forward Rotor Blades	114R1502-9	3600	3600	*	--
	114R1502-13	3600	3600	*	--
	114R1502-15	3600	3600	*	--
	114R1502-17	3600	3600	*	--
	114R1502-23	3600	3600	*	--
	114R1502-25	O/C	O/C	O/C	6000
	114R1502-27	3600	3600	*	--
	114R1502-29	3600	3600	*	--
	114R1502-31	3600	3600	*	--
	114R1502-33	O/C	O/C	O/C	6000
Aft Rotor Blades	114R1502-10	1500	1500	*	--
	114R1502-14	1500	1500	*	--
	114R1502-16	1500	1500	*	--
	114R1502-18	1500	1500	*	--
	114R1502-24	1500	1500	*	--
	114R1502-26	O/C	O/C	O/C	4000
	114R1502-28	1500	1500	*	--
	114R1502-30	1500	1500	*	--
	114R1502-32	1500	1500	*	--
	114R1502-34	O/C	O/C	O/C	4000

* - Not installed in helicopter noted
O/C - On condition removal, see References (2) and (6)

Reasons for Removal Versus Frequency by Blade Removal

It is of primary interest to determine the quantity of blades removed for various reasons. This determination will establish a firm basis for the subsequent calculation of blade means.

This determination took two forms: one, a tabulation of the discrepancies and quantities based upon the reasons for removal, and second, a graphical display of the same information for better understanding of the distributions found.

Calculation of Means

In this study, the calculation of certain means representative of blade operating experience includes the determination of mean-time-between-removals, mean-time-to-removals, and mean-time-between-unscheduled removals. Since nearly all of the same blade removal data is used to derive these various means and their derivations are similar, the derivation of only two of these will be discussed in detail. It should be noted here that blades removed for repair and scrappage are both included.

(1) Calculation of MTBR values.

The mean-time-between-removals (MTBR) for either the forward or aft rotor blades was calculated as three times the sum of all CH-47A or CH-47B/C helicopter operating flight hours accumulated over a selected time period divided by the total quantity of forward or aft blades removed for all causes over that time period of interest. Three times the sum of all helicopter flight hours is required as the CH-47 helicopter uses three-bladed rotors.

Thus, for the forward blades,

$$MTBR_F = \frac{\sum_{j=1}^{N} t_j}{n}$$

where N = Total quantity of helicopters involved

t_j = Flight hours per helicopter

n = Total quantity of forward blades removed

Calculation of the MTBR for the aft blades was accomplished similarly.

(2) Calculation of MTTR values

The mean-time-to-removal (MTTR) was calculated by obtaining each removed blade's operating time (in hours) accumulated up to blade removal and dividing by the quantity of forward or aft blades concerned.

Thus, for the forward blades,

$$MTTR_F = \frac{\sum_{i=1}^{N} t_i}{n}$$

where n = Total quantity of forward rotor blades removed for reason

t_i = Total time in blade flight hours per blade at removal

Calculation of the MTTR for the aft blades was accomplished similarly.

(3) Calculation of MTBUR values

The calculation of mean-time-to-unscheduled removal (MTBUR) was accomplished similarly to the calculation for MTBR discussed above, except that blades removed for scheduled reasons were excluded from the sample of either forward or aft rotor blades.

(4) Calculation of Means Example

To explain the derivation used to obtain the values shown in the subsequent means tabulations in this report, the following example is provided.

Per Table XI, page 34, the mean-time-between-removals of the forward rotor blade ($MTBR_F$) for inherent discrepancies was derived as:

$$MTBR_F = \frac{3\ (341\ X\ 1906 = 650,206.7)}{682} = 2,860\ Hr$$

where 3 is the quantity of rotor blades on the forward rotor, 341 is the quantity of helicopters involved in the operational area and time period being considered (refer to Table II, page 10), 1,906.7 is the average flight time in hours per helicopter, 650,206 is the resultant helicopter flight time accumulated, and 682 is the quantity of forward blades removed for inherent discrepancies.

Determination of Discrepancy Locations Versus Types of Discrepancies

This calculation was primarily concerned with the frequency of discrepancies or damages accumulated for particular blade samples and for various major areas and components of these blades. Both upper and lower surfaces of these blades were shown in the same chart. Forward and aft rotor blades were considered on separate charts. The discrepancy locations for blades that were scrapped for reasons found after removal have been discussed in the scrappage analysis section.

Results of this analysis were tabulated for the various areas as percentages of the total blade experience.

BLADE SCRAPPAGE ANALYSIS APPROACH

Data Limitation and Use

Data included in this portion of the report was derived from the same sources as that used for the blade removal study.

Primarily, the scrappage analyses differ from the removal analyses in that the reasons for scrappage are used as a basis for calculation.

The time period of interest is shown by Table II, page 10.

Determination of Reasons for Scrappage

Reasons for blade scrappage, in general, have the same scope as those for removal as listed in Tables III, page 13, and IV, page 14.

Calculation of Means

Only one set of estimated scrapped blade means is provided, since the scrapped blades are thoroughly investigated as a part of the removal analysis. This one set of means provided is that of mean-time-between-scrappage.

The calculation of the mean-time-between-scrappage (MTBS) applies only to those blades removed and eventually scrapped, whether the reason for scrappage was known beforehand or was determined after further blade inspection and/or blade tear-down.

The calculation was accomplished similar to that for the MTBR as noted above, except that only scrapped blades were included for forward and aft rotors.

ANALYSES

CH-47 BLADE REMOVALS ANALYSES

The analyses presented herein follow the approaches discussed in the preceding section of the report. These analyses are grouped in chronological order of blade development and deployment:

1. CH-47A Forward and Aft Blades

2. CH-47B/C Forward and Aft Blades

Each group provides the following analyses:

a. Major percentage of blade removals

b. Frequency of blade removal vs. removal reasons

c. Mean-Time-Between-Removal

d. Mean-Time-To-Removal

e. Mean-Time-Between-Unscheduled-Removal

Comparisons of the results of these analyses for forward and aft blades and the means are provided.

Table VII provides a review of the number of all blades that have been investigated for removals, repairs and scrappage. The actual accumulated flight time at removal of these blades and the equivalent time on the aircraft is given for comparison.

Note that the number of scrapped blades reviewed are included here for comparison.

TABLE VII. NUMBER OF CH-47A AND CH-47B/C BLADES INVESTIGATED FOR REMOVALS, REPAIRS AND SCRAPPAGE

BLADES		ALL BLADES		ACCUMULATED TIME ON REPAIRED BLADES		ACCUMULATED TIME ON SCRAPPED BLADES		ACCUMULATED TIME ON AIRCRAFT	
HELICOPTER	BLADE LOCATION	QTY.	TIME ON BLADES @ REMOVAL *	QTY.	TIME ON BLADES @ REMOVAL *	QTY.	TIME ON BLADES @ REMOVAL *	HELICOPTER FLIGHT TIME	EQUIVALENT BLADE FLIGHT TIME
CH-47A	Forward	2,126	1,028,473	1,932	945,627	194	82,846	650,206	1,950,618
	Aft	2,349	1,105,419	1,855	870,367	494	235,052	650,206	1,950,618
CH-47B/C	Forward	512	202,775	457	180,292	55	22,483	298,113	894,339
	Aft	501	185,067	430	159,758	71	25,309	294,608	883,824
TOTALS	Forward	2,638	1,231,248	2,389	1,125,919	249	105,329	948,319	2,844,957
	Aft	2,850	1,290,486	2,285	1,030,125	565	260,361	944,814	2,834,442
	All Blades	5,488	2,521,734	4,674	2,128,418	814	365,690	1,893,133	5,679,399

* Time on blades at removal given in blade hours.

CH-47A Forward and Aft Blades Removal Analysis

The removal status of 4,475 blades was reviewed; 2,126 of these were forward blades and 2,349 were aft blades.

Table VIII summarizes the removal status for the most frequently occurring causes of removal for the forward blades. Table IX summarizes similar information for the aft blades.

Figures 4, 5 and 6 illustrate the quantity of forward blades removed for the reasons under study. Figures 7, 8 and 9 illustrate the quantity of aft blades removed for similar reasons. Note that scrapped blade quantities are identified. In these figures the reason for removal of a blade that is scrapped is used, not the reason for scrappage unless they coincide.

A summary of the percentages of CH-47A forward and aft blade removals versus reasons for removal is presented in Table X, page 32. For a comparison to percentages of CH-47B/C forward and aft blade removals, see Table XX on page 55.

TABLE VIII. PERCENTAGES OF FORWARD BLADE REMOVALS - CH-47A

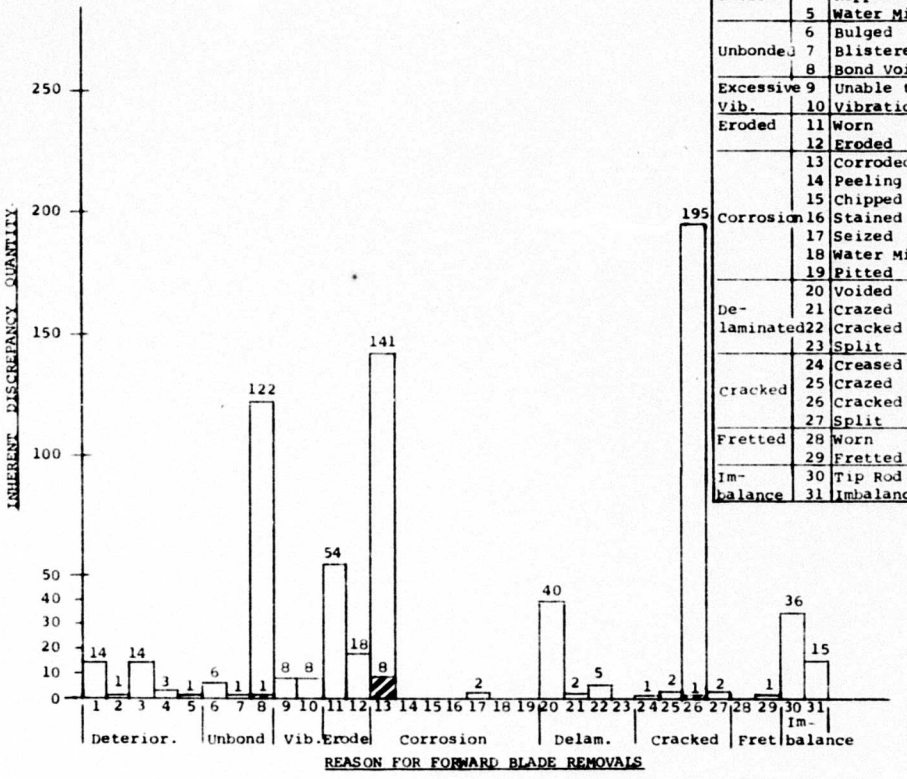
REPAIRED BLADES			SCRAPPED BLADES		
REMOVAL REASON	QTY.	% OF TOTAL REMOVALS	REMOVAL REASON	QTY.	% OF TOTAL REMOVALS
F.O.D. - Dented	330	15.52	F.O.D. - Dented	54	2.54
Sched. Removal (Sched. Maint.)	276	12.98	Overstressed	44	2.06
Cracked	194	9.13	Combat Damage - Punctured	26	1.23
Corrosion	133	6.26	Combat Damage - Dented	20	0.94
Unbonded (Voids)	121	5.69	Crashes/Strikes (Minor Damage)	10	0.47
F.O.D. - Punctures	119	5.60			
Combat Damage - Punctures	80	3.76			
Sched. Removal (Misc.)	70	3.29			
Overstressed	67	3.15			
Sched. Removal (Facilitate Maint.)	58	2.73			
Eroded	54	2.54			
F.O.D. - Scored	52	2.45			
Delaminated (Voided)	40	1.88			
F.O.D. - Bent	38	1.78			
Remainder	300	14.11	Remainder	40	1.88
TOTALS	1,932*	90.87%		194*	9.12%

* Total forward blade removals equals 1,932 + 194 = 2,126.

TABLE IX. PERCENTAGES OF AFT BLADE REMOVALS - CH-47A

REPAIRED BLADES			SCRAPPED BLADES		
REMOVAL REASON	QTY.	% OF TOTAL REMOVALS	REMOVAL REASON	QTY.	% OF TOTAL REMOVALS
Sched. Removal (Maint.)	361	15.37	Overstressed	215	9.15
Cracked	338	14.39	F.O.D. - Dented	93	3.96
F.O.D. - Dented	250	10.64	Sched. Removal (Maint.)	38	1.62
Unbonded (Voids)	138	5.87	Combat Damage - Punctures	31	1.32
Corrosion	92	3.92	Sched. Removal (Retired Blades)	26	1.11
F.O.D. - Punctured	85	3.62	F.O.D. - Punctured	15	0.64
Combat Damage	67	2.85	Combat Damage - Dented	15	0.64
Overstress	64	2.72			
Sched. Removal (Misc.)	60	2.55			
F.O.D. - Scored	46	1.96			
Sched. Removal (MWO Compliance)	30	1.28			
F.O.D. - Torn	29	1.24			
No Valid Removal Reason	26	1.11			
F.O.D. - Bent	24	1.02			
Remainder	245	10.43	Remainder	61	2.59
TOTALS	1,855	78.97%		494	21.03%

* Total aft blade removals equals 1,855 + 494 = 2,349.



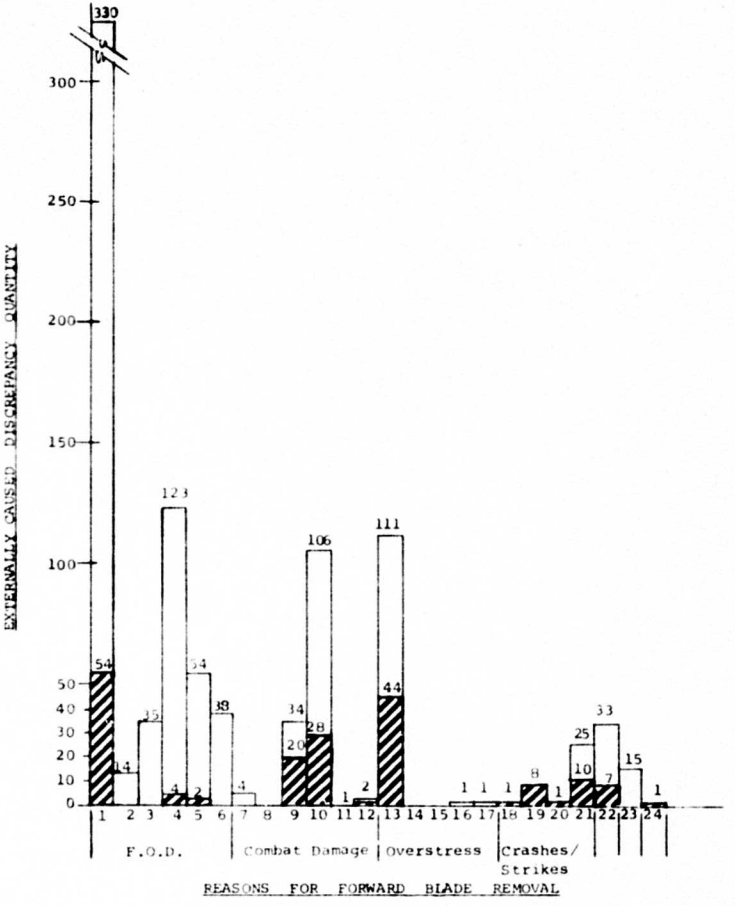
DISTRIBUTION PERCENTAGES

REMOVAL REASONS			REPAIRED BLADES		SCRAPPED BLADES			
Reason	No.	Discrep.	Blade Qty.	% of Internal Discrep.	Blade Qty.	% of Internal Discrep.	Rmvl. Qty.	% of Total Removals
Deterioration	1	Loose/Missing	14	2.05			14	2.02
	2	Bare Steel	1	0.14			1	0.14
	3	Eroded	14	2.05			14	2.02
	4	Rippled	3	0.43			3	0.43
	5	Water Migration	1	0.14			1	0.14
Unbonded	6	Bulged	6	0.87			6	0.87
	7	Blistered	1	0.14			1	0.14
	8	Bond Void	121	17.74	1	10.00	122	17.63
Excessive Vib.	9	Unable to adj	8	1.17			8	1.16
	10	Vibration	8	1.17			8	1.16
Eroded	11	Worn	54	7.91			54	7.80
	12	Eroded	18	2.63			18	2.60
Corrosion	13	Corroded	133	19.50	8	80.00	141	20.38
	14	Peeling						
	15	Chipped						
	16	Stained						
	17	Seized	2	0.29			2	0.28
	18	Water Migration						
	19	Pitted						
De-laminated	20	Voided	40	5.86			40	5.78
	21	Crazed	2	0.29			2	0.28
	22	Cracked	5	0.73			5	0.72
	23	Split						
Cracked	24	Creased	1	0.14			1	0.14
	25	Crazed	2	0.29			2	0.28
	26	Cracked	194	28.44	1	10.00	195	28.18
	27	Split	2	0.29			2	0.28
Fretted	28	Worn						
	29	Fretted	1	0.14			1	0.14
Im-balance	30	Tip Rod Loose	36	5.27			36	5.20
	31	Imbalance	15	2.19			15	2.17
		TOTALS	682	100.00%	10	100.00%	692	100.00%

Repaired Blades

Scrapped Blades

FIGURE 4. INHERENT DISCREPANCY REMOVALS - FORWARD BLADES - CH-47A.



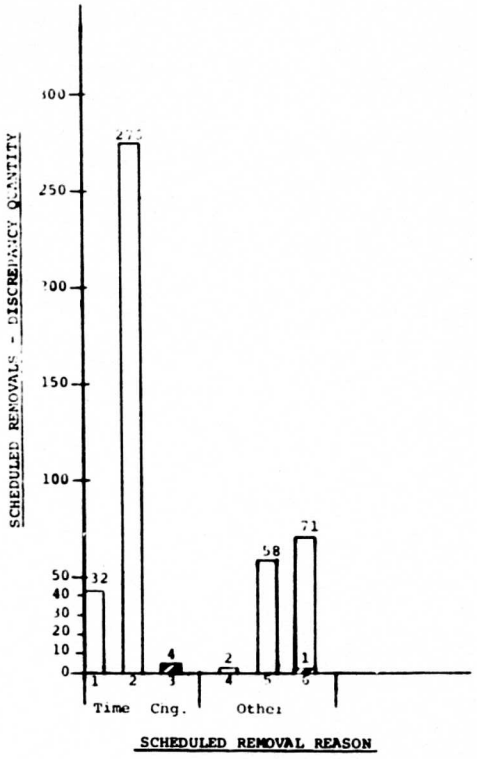
DISTRIBUTION PERCENTAGES

REMOVAL REASON			REPAIRED BLADES		SCRAPPED BLADES			
Reason	No.	Discrep.	Blade Qty.	% of External Discrep.	Blade Qty.	% of External Discrep.	Rmvl. Qty.	% of Total Removals
F.O.D.	1	Dented	330	40.64	54	30.16	384	38.75
	2	Broken	14	1.72			14	1.41
	3	Torn	35	4.31			35	3.53
	4	Punctured	119	14.65	4	2.23	123	12.41
	5	Scored	52	6.40	2	1.11	54	5.45
	6	Bent	38	4.67			38	3.83
Combat Damage	7	Broken	4	0.49			4	0.40
	8	Scored						
	9	Dented	14	1.72	20	11.17	34	3.43
	10	Punctured	80	9.85	26	14.52	106	10.70
	11	Torn						
	12	Spar/Socket	1	0.12	1	0.55	2	0.20
Over-stress	13	Overstress	67	8.25	44	24.58	111	11.20
	14	Bent						
	15	Collapsed						
	16	Fractured	1	0.12			1	0.10
	17	Dented	1	0.12			1	0.10
Crashes/ Strikes	18	Bent			1	0.55	1	0.10
	19	Collapse			8	4.46	8	0.81
	20	Torn			1	0.55	1	0.10
	21	Minor Damage	15	1.84	10	5.58	25	2.52
Error	22	Error *	26	3.20	7	3.91	33	3.33
Not Valid	23	No Valid Rmvl.	15	1.84			15	1.51
Misc.	24	Misc.			1	0.55	1	0.10
		TOTALS	812	100.00%	179	100.00%	991	100.00%

Repaired Blades
Scrapped Blades

* Manufacturing/Shipping/ Handling Error Including Inadequate Field Repair

FIGURE 5. EXTERNAL DISCREPANCY REMOVALS - FORWARD BLADES - CH-47A.

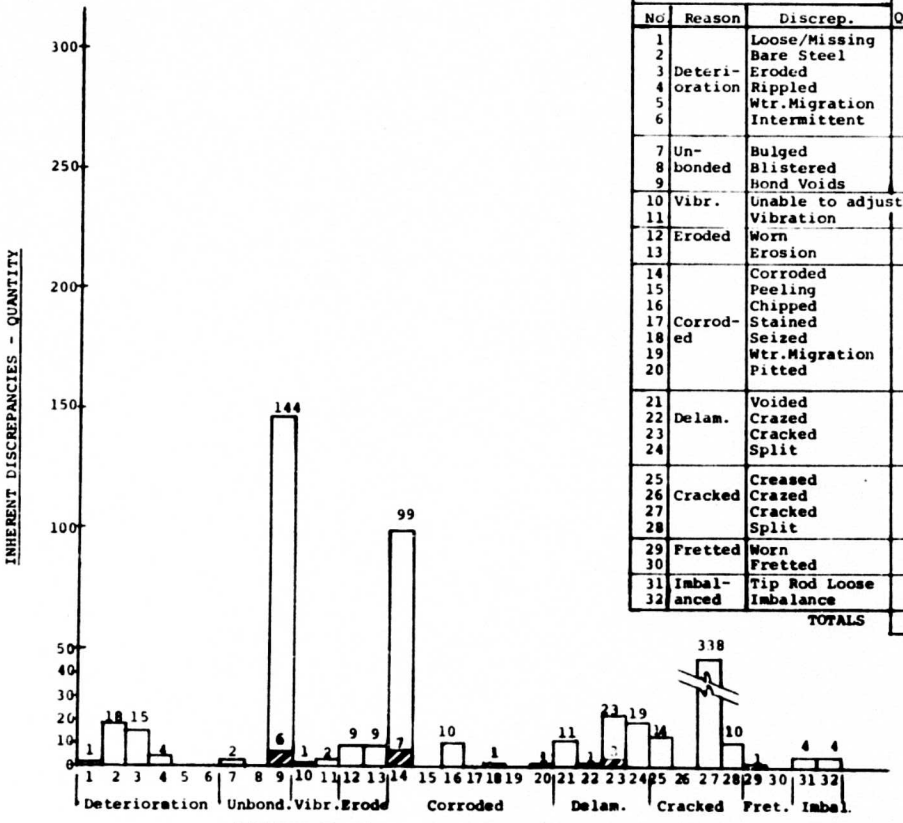


DISTRIBUTION PERCENTAGES

REMOVAL REASON			REPAIRED BLADES		SCRAPPED BLADES			
Reason	No.	Discrepancy	Blade Qty.	% of Sched. Removals	Blade Qty.	% of Sched. Removals	Removal Quantity	% of Total Removals
Time Change	1	MWO Compliance	32	7.24	--	--	32	7.22
	2	No Defect (Sched. Maint.)	276	62.45	--	--	276	62.31
	3	Retired Blades	--	0.90	4	80.00	4	0.90
Other	4	EIR Engr. Evaluation	2	0.45	--	--	2	0.45
	5	No Defect (to facilitate maint.)	58	13.12	--	--	58	13.09
	6	Miscellaneous	70	15.84	1	20.00	71	16.03
		TOTALS	4.38	100.00	5	100.00%	443	100.00%

Repaired Blades
Scrapped Blades

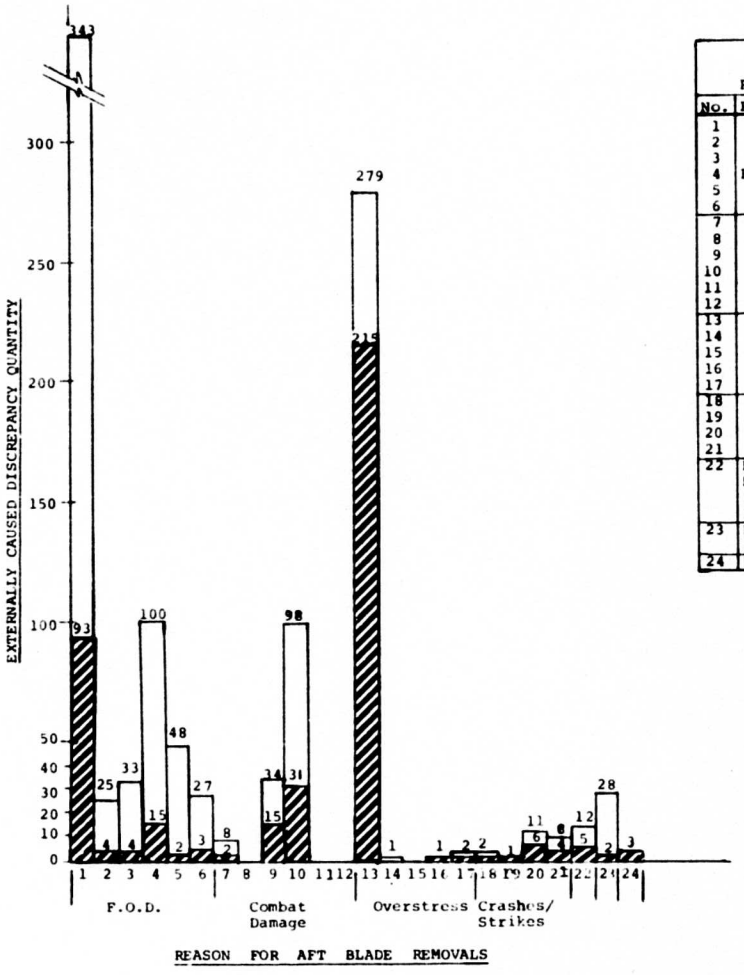
FIGURE 6. SCHEDULED REMOVALS - FORWARD BLADES - CH-47A.



DISTRIBUTION PERCENTAGES

REMOVAL REASON			REPAIRED BLADES		SCRAPPED BLADES		Total	% of
No	Reason	Discrep.	Blade Quantity	% of Inherent Discrep.	Blade Quantity	% of Inherent Discrep.	Quantity Removed	Total Inherent Discrep.
1		Loose/Missing	1	0.14			1	0.13
2		Bare Steel	18	2.48			18	2.43
3	Deteri-	Eroded	15	2.07			15	2.03
4	oration	Rippled	4	0.55			4	0.54
5		Wtr.Migration						
6		Intermittent						
7	Un-	Bulged	2	0.28			2	0.27
8	bonded	Blistered						
9		Bond Voids	138	19.03	6	37.50	144	19.43
10	Vibr.	Unable to adjust	1	0.14			1	0.13
11		Vibration	2	0.28			2	0.27
12	Eroded	Worn	9	1.24			9	1.22
13		Erosion	9	1.24			9	1.22
14		Corroded	92	12.69	7	43.75	99	13.36
15		Peeling						
16		Chipped	10	1.37			10	1.35
17	Corrod-	Stained						
18	ed	Seized	1	0.14			1	0.13
19		Wtr.Migration						
20		Pitted	1	0.14			1	0.13
21		Voided	11	1.52			11	1.49
22	Delam.	Crazed	1	0.14			1	0.13
23		Cracked	20	2.76	3	18.75	23	3.10
24		Split	19	2.62			19	2.56
25		Creased	14	1.93			14	1.89
26	Cracked	Crazed						
27		Cracked	338	46.62			338	45.62
28		Split	10	1.37			10	1.35
29	Fretted	Worn	1	0.14			1	0.13
30		Fretted						
31	Imbal-	Tip Rod Loose	4	0.55			4	0.54
32	anced	Imbalance	4	0.55			4	0.54
		TOTALS	725	100.00%	16	100.00%	741	100.00%

FIGURE 7. INHERENT DISCREPANCY REMOVALS - AFT BLADES - CH-47A.



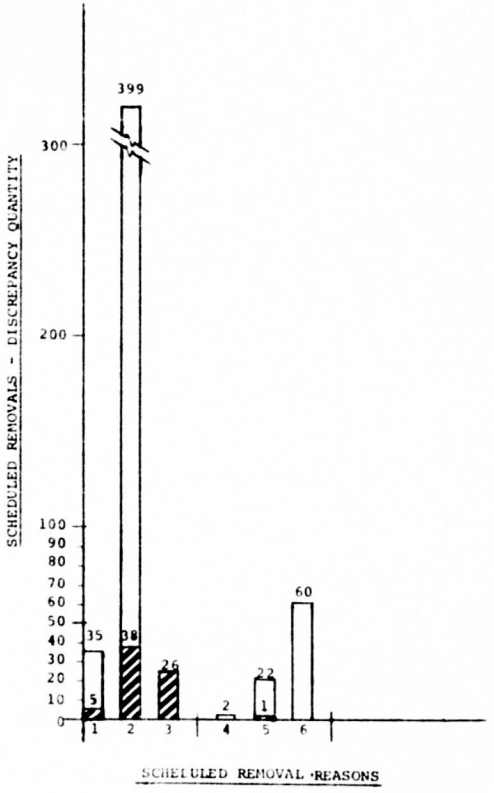
DISTRIBUTION PERCENTAGES

REMOVAL REASON			REPAIRED BLADES		SCRAPPED BLADES		Removal Quantity	% of Total Removal
No.	Reason	Discrep.	Blade Qty.	% of Ext. Discrep.	Blade Qty.	% of Ext. Discrep.		
1	F.O.D.	Dented	250	38.11	93	22.79	343	32.24
2		Broken	21	3.20	4	0.98	25	2.35
3		Torn	29	4.42	4	0.98	33	3.10
4		Punctured	85	12.96	15	3.68	100	9.40
5		Scored	46	7.01	2	0.49	48	4.51
6		Bent	24	3.66	3	0.73	27	2.54
7	Combat Damage	Broken	6	0.92	2	0.49	8	0.75
8		Scored						
9		Dented	19	2.90	15	3 68	34	3.20
10		Punctured	67	10.21	31	7.59	98	9.21
11		Torn						
12		Bent						
13	Over-stress	Overstressed	64	9.76	215	52.69	279	26.22
14		Bent	1	0.15			1	0.09
15		Collapsed						
16		Fractured			1	0.25	1	0.09
17		Dented	1	0.15	1	0.25	2	0.19
18	Crash/ Strike	Bent	1	0.15	1	0.25	2	0.19
19		Collapsed			1	0.25	1	0.09
20		Torn	5	0.76	6	1.47	11	1.03
21		Minor Damage	4	0.61	4	0.98	8	0.75
22	Mfg/Shipping/ Maint. Error Including Inadequate Field Repair		7	1.07	5	1.23	12	1.13
23	No Valid Reason For Removal		26	3.96	2	0.49	28	2.63
24	Unknown				3	0.73	3	0.28
		TOTALS	656	100.00%	408	100.00%	1064	100.00%

Repaired Blades

Scrapped Blades

FIGURE 8. EXTERNAL DISCREPANCY REMOVALS - AFT BLADES - CH-47A



DISTRIBUTION PERCENTAGES

REMOVAL REASON			REPAIRED BLADES		SCRAPPED BLADES			
Reason	No.	Discrepancy	Blade Qty.	% of Scheduled Removals	Blade Qty.	% of Scheduled Removals	Total Qty. Removed	% of Total Removals
Time Change	1	MWO Compliances	30	6.33	5	7.14	35	6.42
	2	No Defect (Scheduled Maintenance)	361	76.16	38	54.29	399	73.35
	3	Retired Blades	--	--	26	37.14	26	4.78
Other	4	EIR Engineering	2	0.42	--	--	2	0.38
	5	No Defect (to facilitate maint.	21	4.43	1	1.43	22	4.04
	6	Miscellaneous	60	12.66	--	--	60	11.03
		TOTALS	474	100.00%	70	100.00%	544	100.00%

Repaired Blades
Scrapped Blades

FIGURE 9. SCHEDULED REMOVALS - AFT BLADES - CH-47A

TABLE X. SUMMARY OF PERCENTAGES OF REMOVALS - CH-47A FORWARD AND AFT ROTOR BLADES

MAJOR DISCREPANCY REMOVAL REASON	FORWARD ROTOR BLADES *						AFT ROTOR BLADES +					
	Total - All Blades		Repaired Blades		Scrapped Blades		Total - All Blades		Repaired Blades		Scrapped Blades	
	Qty.	Pct.	Qty.	Pct.	Qty.	Pct.	Qty.	Pct.	Qty.	Pct.	Qty.	Pct.
Deterioration	33	1.55	33	1.55	--	0	38	1.62	38	1.62	--	0
Unbonded	129	6.07	128	6.02	1	0.05	146	6.22	140	5.60	6	0.26
Vibration	16	0.75	16	0.75	--	0	3	0.13	3	0.13	--	0
Erosion	72	3.39	72	3.39	--	0	18	0.77	18	0.77	--	0
Corrosion	143	6.73	135	6.35	8	0.38	111	4.73	104	4.43	7	0.30
Delaminated	47	2.21	47	2.21	--	0	54	2.30	51	2.17	3	0.13
Cracked	200	9.41	199	9.36	1	0.05	362	15.41	362	15.41	--	0
Fretted	1	0.05	1	0.05	--	0	1	0.04	1	0.04	--	0
Imbalance	51	2.40	51	2.40	--	0	8	0.34	8	0.34	--	0
F.O.D.	648	30.48	588	27.66	60	2.82	576	24.52	455	19.37	121	5.15
Combat Damage	146	6.87	99	4.66	47	2.81	140	5.96	92	3.92	48	2.04
Overstress	113	5.31	69	3.24	44	2.07	283	12.05	66	2.81	217	9.24
Crashes/Strikes	35	1.65	15	0.71	20	0.94	32	0.94	10	0.43	12	0.51
Error	33	1.55	26	1.22	7	0.33	12	0.50	7	0.29	5	0.21
No Valid Reason	15	0.70	15	0.70	--	0	28	1.19	26	1.10	2	0.09
Miscellaneous	1	0.05	--	0	1	0.05	3	0.13	--	0	3	0.13
Time Change	312	14.67	308	14.48	4	0.19	460	19.58	391	16.64	69	2.94
Other	131	6.16	130	6.11	1	0.05	84	3.57	83	3.53	1	0.04
TOTAL	2126	100.00	1932	90.87	194	9.13	2349	100.00	1855	78.97	494	21.04

* Percentages based upon a total of 2,126 forward blades.
\+ Percentages based upon a total of 2,349 aft blades.

CH-47A Forward and Aft Blades Means Analyses

A series of evaluations of the CH-47A rotor blades for their average removal characteristics based upon frequency of blade removal was accomplished. These calculations of the various removal means followed the approach outlined on pages 20 and 21. Results are given in blade hours.

Tables XI, XII, and XIII list the means determined for the major discrepant reasons for removal of CH-47A forward rotor blades.

Tables XIV, XV, and XVI list similar determinations accomplished for the CH-47A aft rotor blades.

Table XVII presents a summary of the results of these analyses for both CH-47A forward and aft blades.

TABLE XI. MEAN-TIME-BETWEEN-REMOVALS - FORWARD BLADES - CH-47A

REASONS FOR REMOVAL	RETURNED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	$MTBR_F$	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	$MTBR_F$	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	$MTBR_F$
Inherent Discrep.	682		2,860	10		195,062	692		2,819
Deterioration	33		59,109				33		59,109
Unbonded	128		15,239	1		1,950,618	129		15,121
Excessive Vibration	16		121,914				16		121,914
Erosion/Wear	72	1,950,618	27,092		1,950,618		72	1,950,618	27,092
Corroded	135		14,449	8		243,827	143		13,641
Delamination	47		41,503				47		41,503
Cracked	199		9,802	1		1,950,618	200		9,753
Fretted	1		1,950,618				1		1,950,618
Imbalance	51		38,247				51		38,247
Externally-Caused Discrep.	771		2,530	171		11,407	942		2,071
Foreign Object Damage	588		3,317	60		32,510	648		3,019
Combat Damage	99	1,950,618	19,703	47	1,950,618	41,503	146	1,950,618	13,369
Overstressed	69		28,270	44		44,332	113		17,262
Crashes/Strikes	15		130,041	20		97,531	35		55,733
No Valid Removal Reason	15	1,950,618	130,041	1	1,950,618	1,950,618	16	1,950,618	121,914
Error*	26	1,950,618	75,024	7	1,950,618	278,660	33	1,950,618	59,109
Scheduled Removal	438		4,453	5		390,124	443		4,403
Time Change	308	1,950,618	6,332	4	1,950,618	487,654	312	1,950,618	6,152
Other	130		15,005	1		1,950,618	131		14,890
All Causes	1,932	1,950,618	1,009	194	1,950,618	10,055	2,126	1,950,618	917

* Manufacturing/Shipping/Handling Error Including Inadequate Field Repair

TABLE XII. MEAN-TIME-TO-REMOVAL - FORWARD BLADES - CH-47A

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Fwd Blade Flight Hours	$MTTR_F$	Qty. of Blades Removed	Total Fwd Blade Flight Hours	$MTTR_F$	Qty. of Blades Removed	Total Fwd Blade Flight Hours	$MTTR_F$
Inherent Discrepancies	682	320,803	470	10	5,476	548	692	326,279	472
Deterioration	33	15,427	467				33	15,427	467
Unbonded	128	59,167	462	1	24	24	129	59,191	459
Excessive Vibration	16	7,267	454				16	7,267	454
Erosion/Wear	72	35,839	498				72	35,839	498
Corrosion	135	64,209	476	8	5,114	639	143	69,323	485
Delamination	47	24,948	531				47	24,948	531
Cracked	199	91,863	462	1	338	338	200	92,201	461
Fretted	1	99	99				1	99	99
Imbalance	51	21,984	431				51	21,984	431
Externally Caused Discrepancies	771	347,103	450	171	60,518	354	942	407,621	433
Foreign Object Damage	588	270,767	460	60	23,572	393	648	294,339	454
Combat Damage	99	40,775	412	47	14,607	311	146	55,382	379
Overstressed	69	30,250	438	44	17,780	404	113	48,030	425
Crashes/Strikes	15	5,311	354	20	4,559	228	35	9,870	282
No Valid Reason for Removal	15	4,011	267	1	267	267	16	4,278	267
Error △	26	7,748	298	7	1,596	228	33	9,344	283
Scheduled Removals	438	265,962	608	5	14,989	2,998	443	280,951	634
MWO Compliance	32	16,894	528				32	16,894	528
Scheduled Maintenance *	276	176,659	640				276	176,659	640
To Facilitate Maintenance *	58	26,524	457				58	26,524	457
EIR	2	1,484	742				2	1,484	742
Retired Blades				4	13,429	3,357	4	13,429	3,357
Miscellaneous *	70	44,401	634	1	1,560	1,560	71	45,961	647
All Causes	1,932	945,627	490	194	82,846	427	2,126	1,028,473	484

* No Defect

△ Manufacturing/Shipping/Handling Error Including Inadequate Field Repair

TABLE XIII. MEAN-TIME-BETWEEN-UNSCHEDULED REMOVAL - FORWARD BLADES - CH-47A

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	$MTBUR_F$	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	$MTBUP_F$	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	$MTBUR_F$
Inherent Discrep.	682		2,860	10		195,062	692		2,819
Deterioration	33		59,109				33		59,109
Unbonded	128		15,239	1		1,950,618	129		15,121
Excessive Vibration	16		121,914				16		121,914
Erosion/Wear	72	1,950,618	27,092		1,950,618		72	1,950,618	27,092
Corroded	135		14,449	8		243,827	143		13,641
Delamination	47		41,503				47		41,503
Cracked	199		9,802	1		1,950,618	200		9,753
Fretted	1		1,950,618				1		1,950,618
Imbalance	51		38,247				51		38,247
Externally-Caused Discrep.	771		2,530	171		11,407	942		2,071
Foreign Object Damage	588		3,317	60		32,510	648		3,010
Combat Damage	99	1,950,618	19,703	47	1,950,618	41,503	146	1,950,618	13,360
Overstressed	69		28,270	44		44,332	113		17,262
Crashes/Strikes	15		130,041	20		97,530	35		55,732
No Valid Removal Reason	15	1,950,618	130,041	1	1,950,618	1,950,618	16	1,950,618	121,914
Error *	26	1,950,618	75,024	7	1,950,618	278,660	33	1,950,618	59,109
All Causes	1,494	1,950,618	1,306	189	1,950,618	10,320	1,683	1,950,618	1,159

* Manufacturing/Shipping/Handling Error Including Inadequate Field Repair.

TABLE XIV. MEAN-TIME-BETWEEN-REMOVAL - AFT BLADES - CH-47A

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Aft Blade Flight Hours	$MTBR_A$	Qty. of Blades Removed	Aft Blade Flight Hours	$MTBR_A$	Qty. of Blades Removed	Total Aft Blade Flight Hours	$MTBR_A$
Inherent Discrepancies	725		2,690	16		121,914	741		2,632
Deterioration	38		51,332				38		51,332
Unbonded	140		13,933	6		325,103	146		13,360
Excessive Vibration	3		650,206				3		650,206
Erosion/Wear	18	1,950,618	180,367		1,950,618		18	1,950,618	108,367
Corrosion	104		18,755	7		278,659	111		17,573
Delamination	51		38,247				51		38,247
Cracked	362		5,388	3		650,206	365		5,344
Fretted	1		1,950,618				1		1,950,618
Imbalance	8		243,827				8		243,827
Externally Caused Discrepancies	623		3,131	398		4,900	1,021		1,910
Foreign Object Damage	455		4,287	121		16,121	576		3,386
Combat Damage	92	1,950,618	21,202	48	1,950,618	40,638	140	1,950,618	13,933
Overstressed	66		29,555	217		8,989	283		6,893
Crashes/Strikes	10		195,062	12		162,552	22		88,664
No Valid Reason for Removal	26	1,950,618	75,024	5	1,950,618	390,124	31	1,950,618	62,923
Error *	7	1,950,618	278,680	5	1,950,618	390,124	12	1,950,618	162,552
Scheduled Removals	474		4,115	70		27,866	544		3,586
MWO Compliance	30		65,000	5		390,124	35		55,732
Scheduled Maintenance	361		5,403	38		51,332	399		4,889
Facilitate Maintenance	21	1,950,618	92,886	1	1,950,618	1,950,618	22	1,950,618	88,664
EIR	2		975,309				2		975,309
Retired				26		75,024	26		75,024
Miscellaneous	60		32,510				60		32,510
All Causes	1,855	1,950,618	1,052	494	1,950,618	3,950	2,349	1,950,618	830

* Manufacturing/Shipping/Handling Error Including Inadequate Field Repair.

TABLE XV. MEAN-TIME-TO-REMOVAL - AFT BLADES - CH-47A

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Aft Bld. Flight Hours	$MTTR_A$	Qty. of Blades Removed	Total Aft Bld. Flight Hours	$MTTR_A$	Qty. of Blades Removed	Total Aft Bld. Flight Hours	$MTTR_A$
Inherent Discrep.	725	442,206	610	16	5,550	347	741	447,756	604
Deterioration	38	23,168	610				38	23,168	610
Unbonded	140	80,038	572	6	1,703	284	146	81,741	560
Excessive Vibration	3	1,851	617				3	1,851	617
Erosion/Wear	18	10,436	580				18	10,436	580
Corrosion	104	69,682	670	7	2,382	340	111	72,064	649
Delamination	51	33,958	666				51	33,958	666
Cracked	362	218,001	602	3	1,465	488	365	219,466	601
Fretted	1	202	202				1	202	202
Imbalance	8	4,870	609				8	4,870	610
Externally-Caused Discrepancies	623	211,296	339	398	144,816	364	1,021	356,112	349
Foreign Object Damage	455	157,344	346	121	44,321	366	576	201,665	350
Combat Damage	92	30,886	336	48	17,041	355	140	47,927	342
Overstressed	66	20,187	306	217	79,069	364	283	99,256	351
Crashes/Strikes	10	2,879	288	12	4,385	365	22	7,264	330
No Valid Removal Reason	26	9,860	379	5	2,557	511	31	12,417	401
Error *	7	2,748	393	5	2,057	411	12	4,805	400
Scheduled Removals	474	204,257	431	70	80,072	1,144	544	284,329	523
MWO Compliance	30	8,411	280	5	1,492	298	35	9,903	283
Scheduled Maintenance	361	160,818	445	38	18,885	497	399	179,703	450
Facilitate Maintenance	21	6,859	327	1	294	294	22	7,153	325
EIR	2	543	272				2	543	272
Miscellaneous	60	27,626	460				60	27,626	460
Retired Blades				26	59,401	2,285	26	59,401	2,284
TOTAL All Causes	1,855	870,367	469	494	235,052	476	2,349	1,105,419	471

* Manufacturing/Shipping/Handling Error Including Inadequate Field Repair.

TABLE XVI. MEAN-TIME-BETWEEN-UNSCHEDULED-REMOVAL - AFT BLADES - CH-47A

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Aft Blade Flight Hours	$MTBUR_A$	Qty. of Blades Removed	Total Aft Blade Flight Hours	$MTBUR_A$	Qty. of Blades Removed	Total Aft Blade Flight Hours	$MTBUR_A$
Inherent Discrepancies	725		2,690	16		121,914	741		2,632
Deterioration	38		51,332				38		51,332
Unbonded	140		13,933	6		325,103	146		13,360
Excessive Vibration	3		650,206				3		650,206
Erosion/Wear	18		180,367				18		108,367
Corroded	104	1,950,618	18,755	7	1,950,618	278,659	111	1,950,618	17,573
Delamination	51		38,247				51		38,247
Cracked	362		5,388	3		650,206	365		5,344
Fretted	1		1,950,618				1		1,950,618
Imbalance	8		243,827				8		243,827
Externally-Caused Discrepancies	623		3,131	398		4,900	1,021		1,910
Foreign Object Damage	455		4,287	121		6,121	576		3,386
Combat Damage	92	1,950,618	21,202	48	1,950,618	40,638	140	1,950,618	13,933
Overstressed	66		29,555	217		8,989	283		6,893
Crashes/Strikes	10		195,062	12		162,552	22		88,664
No Valid Removal Reason	26	1,950,618	75,024	5	1,950,618	390,124	31	1,950,618	62,923
Error *	7	1,950,618	278,659	5	1,950,618	390,124	12	1,950,618	162,552
All Causes	1,381	1,950,618	1,412	424	1,950,618	4,600	1,805	1,950,618	1,080

* Manufacturing/shipping/handling error including inadequate field repair

TABLE XVII. SUMMARY OF CH-47A FORWARD AND AFT BLADE MEANS

BLADE			COMBINED VALUES	INHERENT DISCREPANCY	EXTERNALLY CAUSED DISCREPANCY	ERROR CAUSED DISCREPANCY	SCHEDULED REMOVALS	NO VALID REMOVAL REASON
FORWARD BLADES	$MTBR_F$	Repaired	1,009	2,860	2,530	75,024	4,453	130,041
		Scrapped	10,055	195,062	11,407	278,660	390,124	1,950,618
		Total	917	2,819	2,071	59,109	4,403	121,914
	$MTTR_F$	Repaired	490	470	450	298	608	267
		Scrapped	427	548	354	228	2,997	267
		Total	484	472	433	283	634	267
	$MTBUR_F$	Repaired	1,306	2,860	2,530	75,024	N.A.	130,041
		Scrapped	10,320	195,062	11,407	278,660	N.A.	1,950,618
		Total	1,159	2,819	2,071	59,109	N.A.	121,914
AFT BLADES	$MTBR_A$	Repaired	1,052	2,690	3,131	278,659	4,115	75,024
		Scrapped	3,950	121,914	4,900	390,135	27,866	390,124
		Total	830	2,632	1,910	162,552	3,586	62,923
	$MTTR_A$	Repaired	469	610	339	393	431	379
		Scrapped	476	347	364	411	1,144	511
		Total	471	604	349	400	523	401
	$MTBUR_A$	Repaired	1,412	2,690	3,131	278,659	N.A.	75,024
		Scrapped	4,600	121,914	4,900	390,124	N.A.	390,124
		Total	1,080	2,632	1,910	162,552	N.A.	62,923

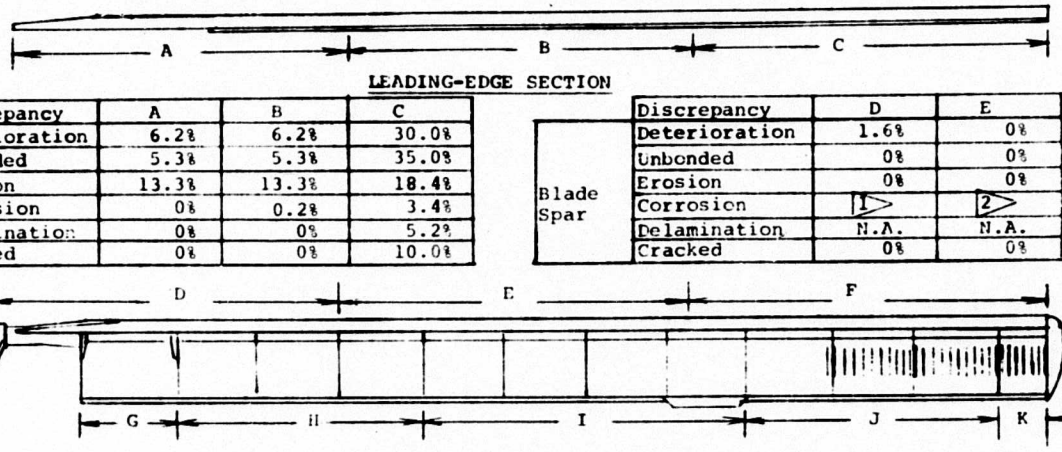
N.A. - Not Applicable
MTBR - Mean-Time-Between Removals
MTTR - Mean-Time-To-Removal
MTBUR - Mean-Time-Between Unscheduled Removals

Discrepancy Locations Versus Types of Discrepancies

Data included herein has been based upon 'Reasons for Removal' only.

This investigation simplified the amount of data handled by confining the results to discrepancy locations versus types of inherent discrepancies and to externally-caused discrepancies only.

Figures 10 and 11 illustrate the results obtained for the CH-47A forward blades. Figures 12 and 13 illustrate similar results obtained for the CH-47A aft blades.



LEADING-EDGE SECTION

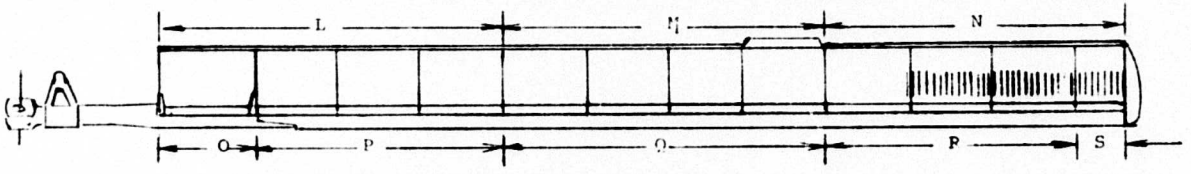
	Discrepancy	A	B	C
Leading Edge	Deterioration	6.2%	6.2%	30.0%
	Unbonded	5.3%	5.3%	35.0%
	Erosion	13.3%	13.3%	18.4%
	Corrosion	0%	0.2%	3.4%
	Delamination	0%	0%	5.2%
	Cracked	0%	0%	10.0%

	Discrepancy	D	E	F
Blade Spar	Deterioration	1.6%	0%	0%
	Unbonded	0%	0%	0%
	Erosion	0%	0%	0.3%
	Corrosion	1	2	3
	Delamination	N.A.	N.A.	N.A.
	Cracked	0%	0%	0%

BLADE PLAN VIEW

	Discrepancy	G	H	I	J	K
Upper Box Surface	Deterioration	0.8%	1.6%	5.0%	4.0%	6.0%
	Unbonded	0.5%	1.0%	5.3%	4.9%	7.4%
	Erosion	0.8%	1.5%	0%	0%	0%
	Corrosion	0%	0%	1.1%	0.5%	0.7%
	Delamination	2.6%	7.8%	21.0%	4.4%	6.3%
	Cracked	4.0%	8.0%	4.0%	1.6%	2.4%

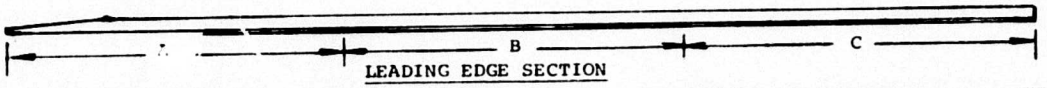
	Discrepancy	L	M	N
Trailing Edge	Deterioration	1.6%	1.6%	2.5%
	Unbonded	1.7%	1.7%	0.2%
	Erosion	0%	0%	0%
	Corrosion	0%	0%	0%
	Delamination	0%	0%	0%
	Cracked	0%	24.0%	6.0%



	Discrepancy	O	P	Q	R	S
Lower Box Surface	Deterioration	1.2%	6.2%	9.3%	6.2%	10.0%
	Unbonded	2.1%	5.8%	6.3%	7.0%	10.5%
	Erosion	0.8%	4.3%	10.5%	14.7%	22.1%
	Corrosion	1.1%	2.3%	5.7%	4.6%	6.9%
	Delamination	6.0%	12.4%	16.0%	7.3%	11.0%
	Cracked	6.0%	12.0%	8.0%	5.6%	8.4%

1 15% for spar exterior, 18.4% spar int.
2 9.1% for spar exterior, 9.2% spar int.
3 12.6% for spar exterior, 9.2% spar int.
N.A. = Not Applicable

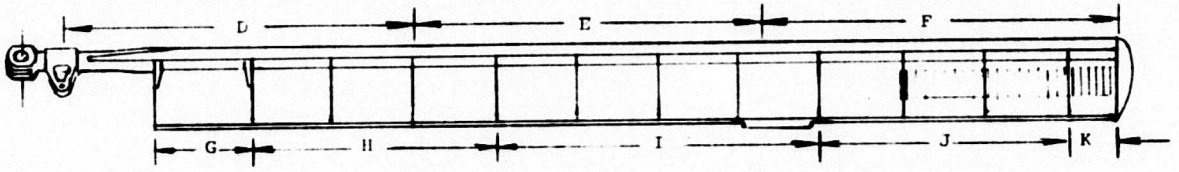
FIGURE 10. INHERENT DISCREPANCY LOCATIONS - FORWARD BLADES - CH-47A.



LEADING EDGE SECTION

	Discrepancy	A	B	C
Leading Edge	F.O.D.	0%	2.2%	21.0%
	Combat Dam.	1.2%	2.4%	4.8%
	Overstress	N.A.	N.A.	N.A.
	Crash/Strike	0%	0%	33%
	Error	0%	0%	10%

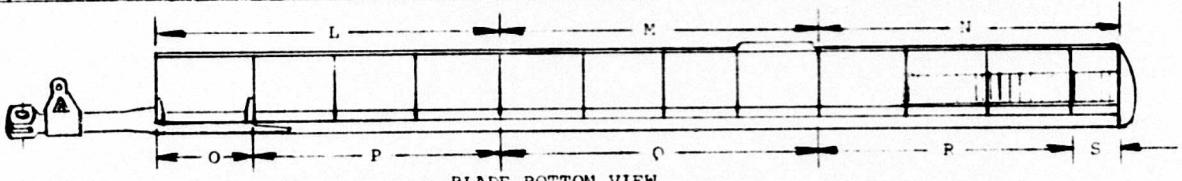
	Discrepancy	D	E	F
Blade Spar	F.O.D.	0.5%	0.5%	1.6%
	Combat Damage	0%	0%	0%
	Overstress	100%	0%	0%
	Crashes/Strikes	0%	0%	0%
	Error	0%	0%	0%



BLADE PLAN VIEW

	Discrepancy	G	H	I	J	K
Upper Box Surfaces	F.O.D.	1.6%	3.3%	8.3%	5.5%	7.8%
	Combat Damage	3.5%	8.3%	7.1%	5.7%	8.5%
	Overstress	N.A.	N.A.	N.A.	N.A.	N.A.
	Crashes/Strikes	0%	0%	33%	0%	0%
	Error	0%	0%	0%	4%	6%

	Discrepancy	L	M	N
Trailing Edge	F.O.D.	4.4%	2.2%	5.0%
	Combat Damage	2.4%	2.4%	1.2%
	Overstress	N.A.	N.A.	N.A.
	Crashes/Strikes	0%	0%	0%
	Error	10%	0%	10%



BLADE BOTTOM VIEW

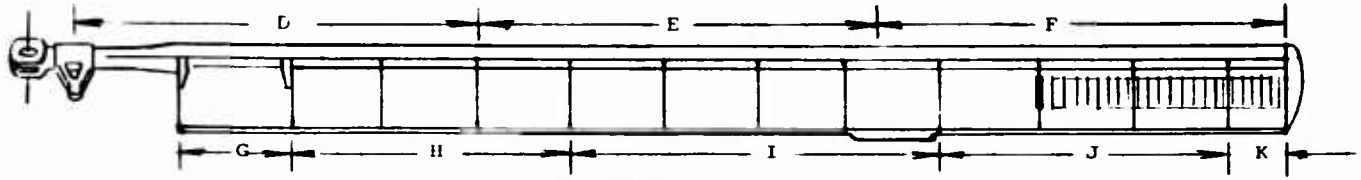
	Discrepancy	O	P	Q	R	S
Lower Box Surfaces	F.O.D.	3.3%	6.5%	11.5%	6.5%	9.3%
	Combat Damage	5.0%	11.7%	21.4%	5.7%	8.7%
	Overstress	N.A.	N.A.	N.A.	N.A.	N.A.
	Crashes/Strikes	0%	0%	34%	0%	0%
	Error	0%	0%	10%	20%	30%

FIGURE 11. EXTERNAL DISCREPANCY LOCATIONS - FORWARD BLADES - CH-47A.

LEADING EDGE SECTION

	Discrepancy	A	B	C
Leading Edge	Deterioration	0%	0%	5.8%
	Unbonded	1.3%	0%	6.6%
	Erosion	17.0%	17.0%	17.0%
	Corrosion	0%	0%	0%
	Delamination	0%	0%	1.0%
	Cracked 6	0%	0%	5.0%

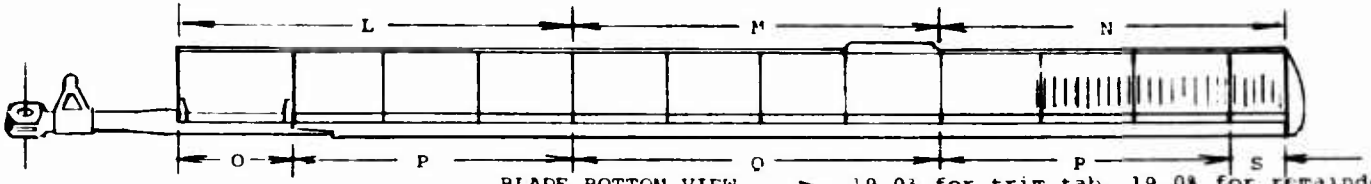
	Discrepancy	D	E	F
Blade Spar	Deterioration	0%	0%	0%
	Unbonded	0%	0%	0%
	Erosion	0%	0%	0%
	Corrosion	26.0% 3	15.0% 4	50.0% 5
	Delamination	N.A.	N.A.	N.A.
	Cracked	--	--	--



BLADE PLAN VIEW

	Discrepancy	G	H	I	J	K
Upper Box Surfaces	Deterioration	3.0%	7.0%	2.5%	4.2%	7.8%
	Unbonded	2.4%	6.0%	2.2%	9.7%	17.8%
	Erosion	0%	0%	0%	0%	0%
	Corrosion	0%	0%	0%	1.5%	3.0%
	Delamination	1.6%	2.8%	0%	3.0%	3.0%
	Cracked	0.6%	1.8%	0%	3.4%	4.6%

	Discrepancy	L	M	N
Trailing Edge	Deterioration	0%	0%	0%
	Unbonded	1.3%	0%	0%
	Erosion	0%	0%	0%
	Corrosion	0%	0%	0%
	Delamination	2.0%	4.0%	5.0%
	Cracked	2.4%	38.0%	3.7%

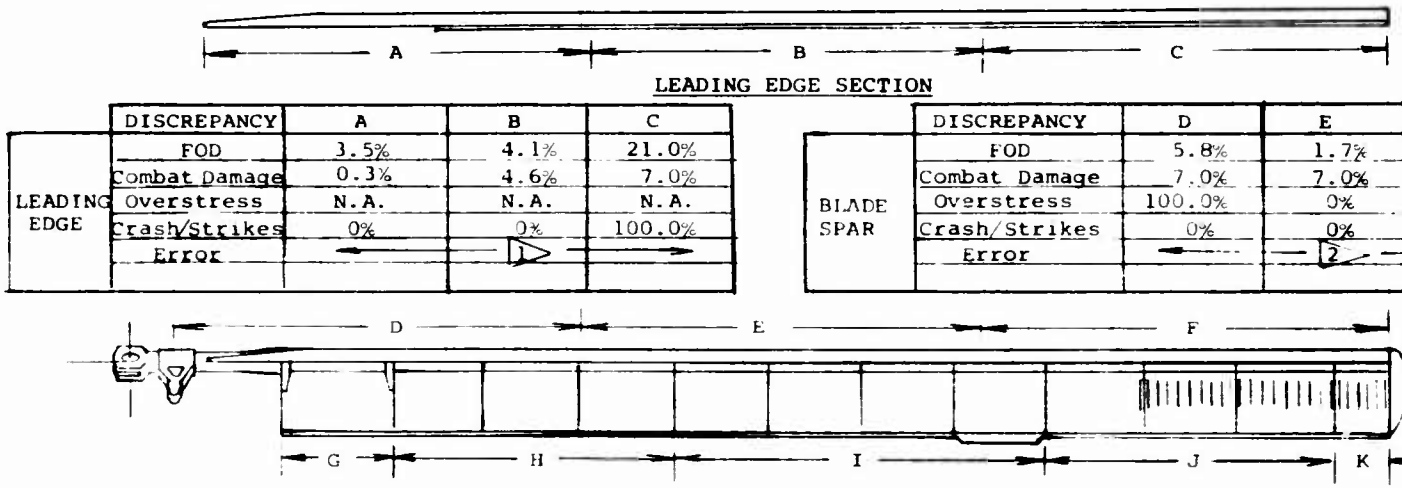


BLADE BOTTOM VIEW

	Discrepancy	O	P	Q	R	S
Lower Box Surfaces	Deterioration	10.0%	15.0%	2.7%	7.0%	35.0%
	Unbonded	4.3%	12.0%	6.5%	10.3%	19.6%
	Erosion	0%	0%	0%	17.0%	32.0%
	Corrosion	0%	0%	0%	1.0%	3.0%
	Delamination	5.3%	9.7%	2.0%	20.0%	40.0%
	Cracked	2 1.3%	2 2.2%	4.0% 2	4.0% 2	2 4.8%

1 19.0% for trim tab, 19.0% for remainder of box T.E.
2 Ribs only
3 17.0% exterior, 9.0% interior
4 4.5% exterior, 9.0% interior
5 30.0% exterior, 20.0% interior
6 7.4% for tip cover cracking
N.A.=Not Applicable

FIGURE 12. INHERENT DISCREPANCY LOCATIONS - AFT BLADES - CH-47A.



LEADING EDGE SECTION

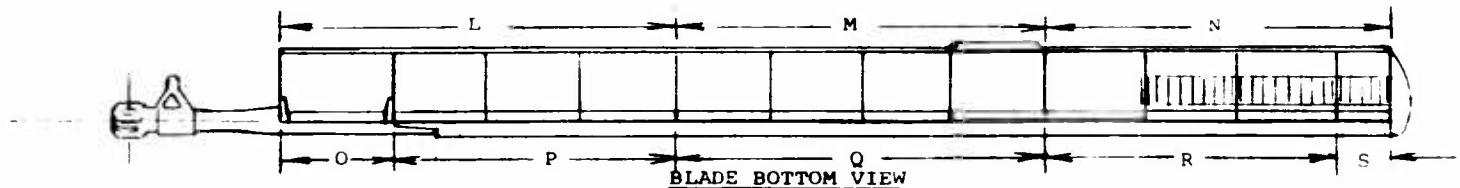
	DISCREPANCY	A	B	C
LEADING EDGE	FOD	3.5%	4.1%	21.0%
	Combat Damage	0.3%	4.6%	7.0%
	Overstress	N.A.	N.A.	N.A.
	Crash/Strikes	0%	0%	100.0%
	Error	←	1	→

	DISCREPANCY	D	E	F
BLADE SPAR	FOD	5.8%	1.7%	7.0%
	Combat Damage	7.0%	7.0%	2.3%
	Overstress	100.0%	0%	0%
	Crash/Strikes	0%	0%	0%
	Error	←	2	→

BLADE PLAN VIEW

	DISCREPANCY	G	H	I	J	K
UPPER BOX SURFACES	FOD	0.7%	2.8%	5.8%	4.2%	6.3%
	Combat Damage	1.4%	5.6%	7.0%	2.8%	4.2%
	Overstress	N.A.	N.A.	N.A.	N.A.	N.A.
	Crash/Strikes	0%	0%	0%	0%	0%
	Error	←		1		→

	DISCREPANCY	L	M	N
TRAIL. EDGE	FOD	1.1%	2.8%	2.8%
	Combat Damage	0%	2.3%	0%
	Overstress	N.A.	N.A.	N.A.
	Crash/Strikes	0%	0%	0%
	Error	←	2	→



BLADE BOTTOM VIEW

	DISCREPANCY	O	P	Q	R	S
LOWER BOX SURFACES	FOD	0.9%	4.3%	7.3%	8.1%	9.8%
	Combat Damage	2.3%	9.2%	16.0%	8.5%	12.5%
	Overstress	N.A.	N.A.	N.A.	N.A.	N.A.
	Crash/Strikes	0%	0%	0%	0%	0%
	Error	←		2		→

1 — 1.7% for Trim Tab. 1.1% for remainder of T. E

2 — Insufficient data to determine distribution

N.A. = Not Applicable

FIGURE 13. EXTERNAL DISCREPANCY LOCATIONS - AFT BLADES - CH-47A.

CH-47B/C Forward and Aft Blades Removal Analysis

The removal status of 1,013 rotor blades was reviewed, 512 of which were forward blades and 501 were aft blades.

Table XVIII summarizes the removal status for the most frequently occurring causes of removal of the forward blades. Table XIX summarizes similar information for the aft blades.

Figures 14, 15 and 16 illustrate the quantity of forward blades removed for the reasons under study. Figures 17, 18, and 19 illustrate the quantity of aft blades removed for similar reasons. Note that scrapped blade quantities are identified. In these figures the reason for removal of a blade that is scrapped is used, not the reason for scrappage unless they coincide.

A summary of the percentages of CH-47B/C forward and aft blade removals versus reasons for removal is presented in Table XX, on page 55; for a comparison to the percentages of CH-47A forward and aft blade removals, see Table X, page 32.

TABLE XVIII. PERCENTAGES OF FORWARD BLADE REMOVALS - CH-47B/C

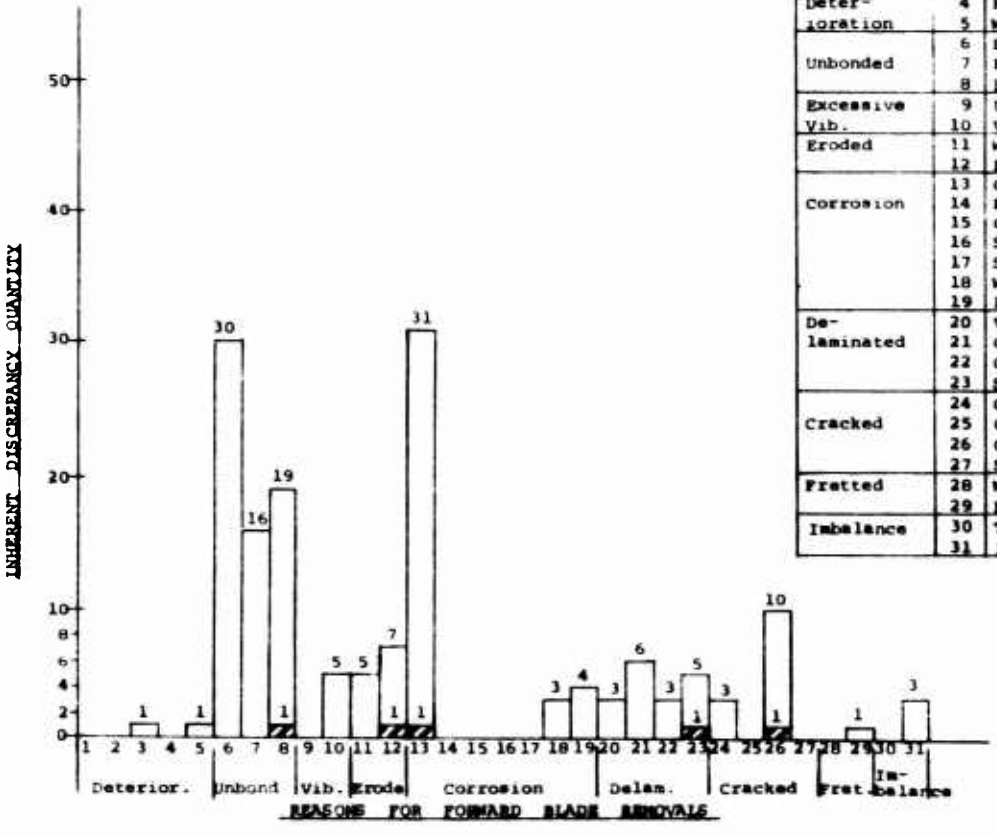
REPAIRED BLADES			SCRAPPED BLADES		
REMOVAL REASON	QTY.	% OF TOTAL REMOVALS *	REMOVAL REASON	QTY.	% OF TOTAL REMOVALS *
F.O.D. Denting	106	20.70	Combat Damage Punctures	17	3.32
F.O.D. Punctures	30	5.86	F.O.D. Denting	12	2.34
Combat Damage Punct.	30	5.86	Combat Damage - Dent	10	1.95
Unbond.(Bulged) Boxes	30	5.86	F.O.D. - Punctured	4	0.78
Corrosion	30	5.86	Overstress	3	0.59
Overstress	29	5.66	Manuf/Ship/Maint Error	3	0.59
No Defect-Sched.Maint.	23	4.49			
Box - Bond Voids	18	3.52			
Unbonded - Blistered	16	3.13			
No Valid Rem. Reason	16	3.13			
Combat Damage - Dent	14	2.73			
F.O.D. Torn	13	2.54			
No Defect - To Facilitate Maint.	10	1.95			
Remainder	92	17.97	Remainder	6	1.17
TOTALS	457	89.26%		55	10.74%

* Total forward blade removals equals 457 + 55 = 512

TABLE XIX. PERCENTAGES OF AFT BLADE REMOVALS - CH-47B/C

REPAIRED BLADES			SCRAPPED BLADES		
REMOVAL REASON	QTY.	% OF TOTAL REMOVALS *	REMOVAL REASON	QTY.	% OF TOTAL REMOVALS *
F.O.D. Denting	91	18.16	F.O.D. Dented	23	4.59
Unbonded Boxes	39	7.78	Crashes/Strikes -	13	2.60
F.O.D. Punctures	35	6.99	Minor Damage		
Combat Damage - Punct.	34	6.79	Combat Damage - Dents	9	1.80
Overstress	27	5.39	Combat Damage - Punct.	8	1.59
Unbonded (Bulged) Boxes	26	5.19	Internal Discrep. Corr.	3	0.60
No Valid Removal Reason	23	4.59	F.O.D. - Punctures	3	0.60
No Defect (Sched. Maint.)	22	4.39			
Corrosion	17	3.39			
Unbonded (Voids) Boxes	14	2.79			
MWO Compliance	13	2.60			
Combat Damage - Dents	13	2.60			
Delaminated (Voids)	9	1.80			
Remainder	67	13.37	Remainder	12	2.40
TOTALS	430	85.83%		71	14.17%

* Total aft blade removals equals 430 + 71 = 501 blades

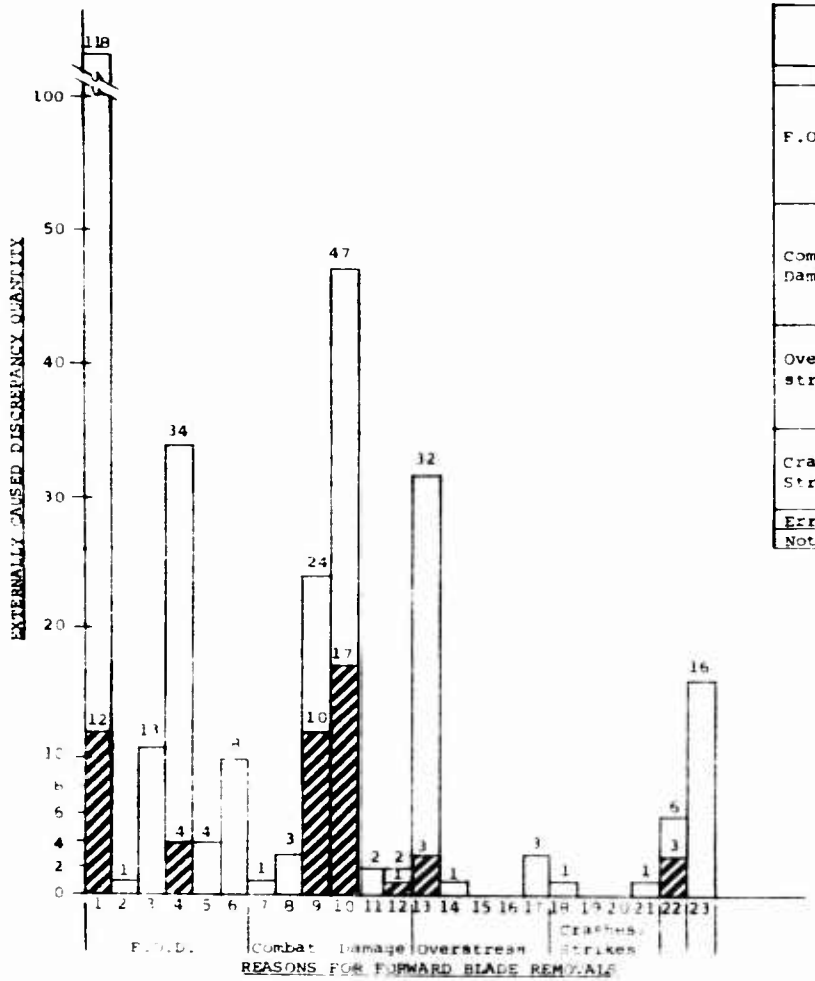


DISTRIBUTION PERCENTAGES

REMOVAL REASON			RETURNED BLADES		SCRAPPED BLADES			
Reason	No.	Discrep.	Blade Qty.	% of Inherent Discrep.	Blade Qty.	% of Inherent Discrep.	Rmvl Qty.	% of Total Rmvl.
Deterioration	1	Loose/Missing						
	2	Bare Steel						
	3	Eroded	1	0.66			1	0.64
	4	Rippled						
	5	Water Migrate	1	0.66			1	0.64
Unbonded	6	Bulged	30	19.87			30	19.23
	7	Blistered	16	10.60			16	10.26
	8	Bond Void	18	11.92	1	20.00	19	12.18
Excessive Vib.	9	Unable to adj.						
	10	Vibration	5	3.31			5	3.20
Eroded	11	Worn	5	3.31			5	3.20
	12	Eroded	6	3.97	1	20.00	7	4.49
Corrosion	13	Corroded	30	19.87	1	20.00	31	19.87
	14	Peeling						
	15	Chipped						
	16	Stained						
	17	Seized						
	18	Water Migrate	3	1.99			3	1.92
	19	Pitted	4	2.65			4	2.56
Delaminated	20	Voided	3	1.99			3	1.92
	21	Crazed	6	3.97			6	3.85
	22	Cracked	3	1.99			3	1.92
	23	Split	4	2.65	1	20.00	5	3.20
Cracked	24	Creased	3	1.99			3	1.92
	25	Crazed						
	26	Cracked	9	5.96	1	20.00	10	6.41
	27	Split						
Fretted	28	Worn						
	29	Fretted	1	0.66			1	0.64
Imbalance	30	Tip Rod Loose						
	31	Imbalance	3	1.99			3	1.92
		TOTALS	151	100.00%	5	100.00%	156	100.00%

Repaired Blades
Scrapped Blades

FIGURE 14. INHERENT DISCREPANCY-CAUSED REMOVALS - FORWARD BLADES - CH-47 B/C.



DISTRIBUTION PERCENTAGE

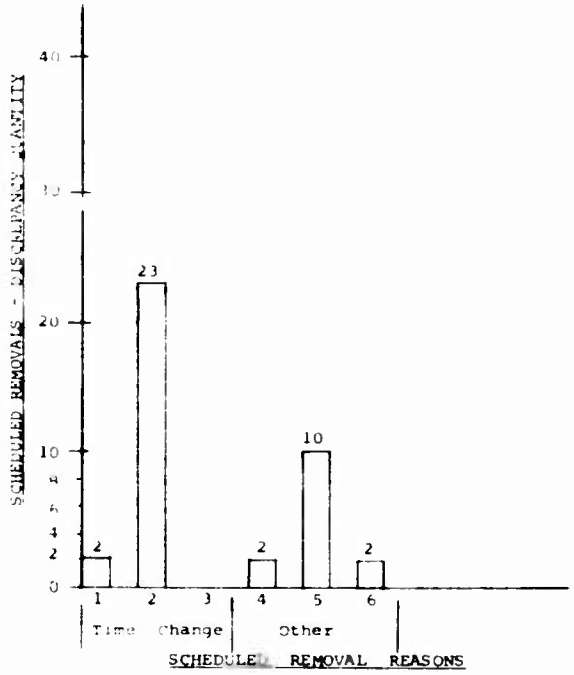
REMOVAL REASON			REPAIRED BLADES		SCRAPPED BLADES			
Reason	No.	Discrep.	Blade Qty.	% of Extern. Discrep.	Blade Qty.	% of External Discrep.	Rmvl Qty.	% of Total Removals
F.O.D.	1	Dented	106	39.70	12	24.00	118	37.22
	2	Broken	1	0.38			1	0.32
	3	Torn	13	4.87			13	4.10
	4	Punctured	30	11.23	4	8.00	34	10.73
	5	Scored	4	1.50			4	1.26
	6	Bent	8	2.99			8	2.52
Combat Damage	7	Broken	1	0.38			1	0.32
	8	Scored	3	1.12			3	0.94
	9	Dented	14	5.24	10	20.00	24	7.57
	10	Punctured	30	11.23	17	34.00	47	14.83
	11	Torn	2	0.75			2	0.64
	12	Spar/Socket	1	0.38	1	2.00	2	0.64
Over-stress	13	Overstress	29	10.86	3	6.00	32	10.09
	14	Bent	1	0.38			1	0.32
	15	Collapse						
	16	Fractured						
	17	Dented	3	1.12			3	0.94
Crashes/ Strikes	18	Bent	1	0.38			1	0.32
	19	Collapse						
	20	Torn						
	21	Minor Damage	1	0.38			1	0.32
Error	22	Error *	3	1.12	3	6.00	6	1.88
Not Valid	23	No Valid Rmv.	16	5.99			16	5.04
		TOTALS	267	100.00%	50	100.00%	317	100.00%

Repaired Blades

Scrapped Blades

* Manufacturing/Shipping/ Handling Error Including Inadequate Field Maintenance

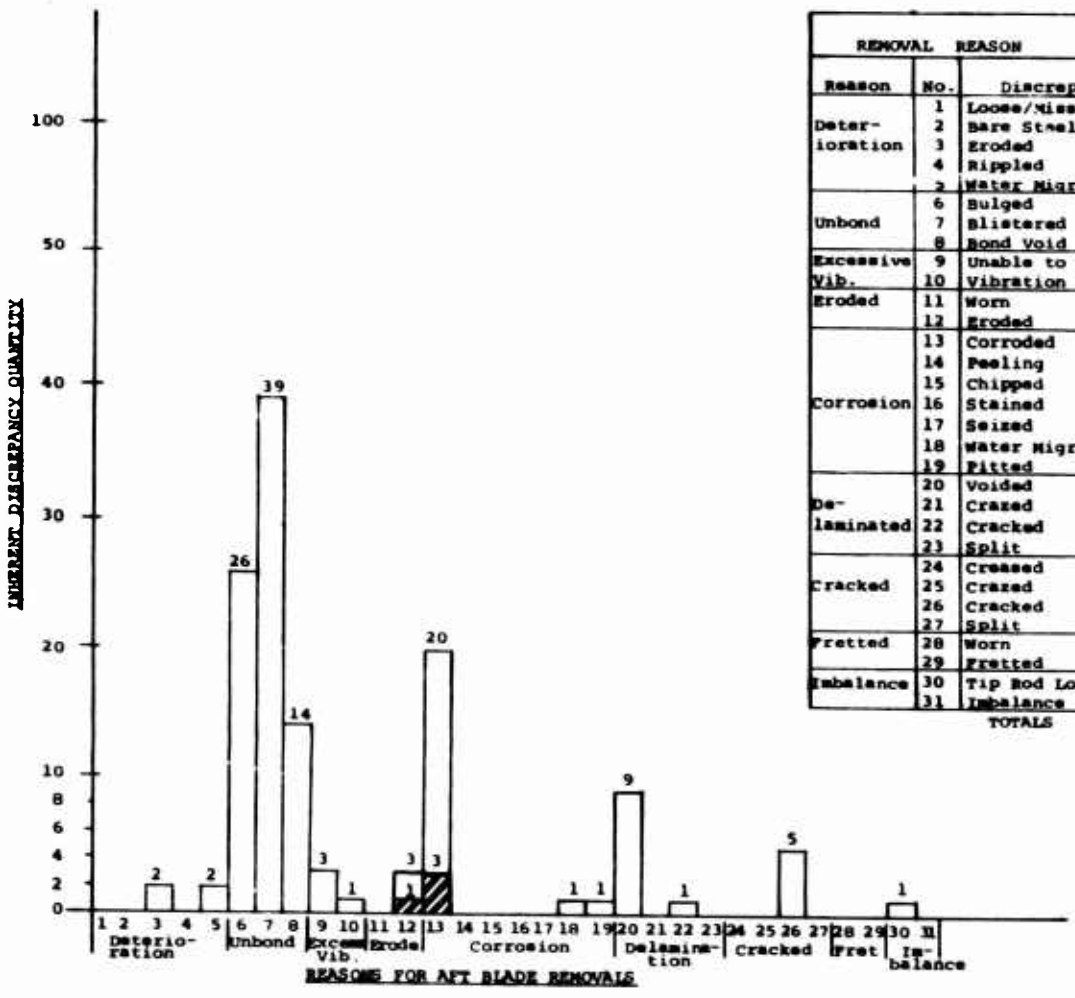
FIGURE 15. EXTERNALLY-CAUSED DISCREPANCY REMOVALS - FORWARD BLADES - CH-47 B/C.



DISTRIBUTION PERCENTAGES

REMOVAL REASON			REPAIRED BLADES		SCRAPPED BLADES			
Reason	No.	Discrep.	Blade Qty.	% of Scheduled Removals	Blade Qty.	% of Scheduled Removals	Rmvl. Qty.	% of Total Removals
Time Change	1	MNO Compliance	2	5.13			2	5.13
	2	No Defect (Scheduled Maintenance)	23	58.97			23	58.97
	3	Retired Blades						
Other	4	EIR Engr. Evaluation	2	5.13			2	5.13
	5	No Defect - (To facilitate maint.)	10	25.64			10	25.64
	6	Miscellaneous	2	5.13			2	5.13
		TOTALS	39	100.00%			39	100.00%

FIGURE 16. SCHEDULED REMOVALS - FORWARD BLADES - CH-47 B/C.

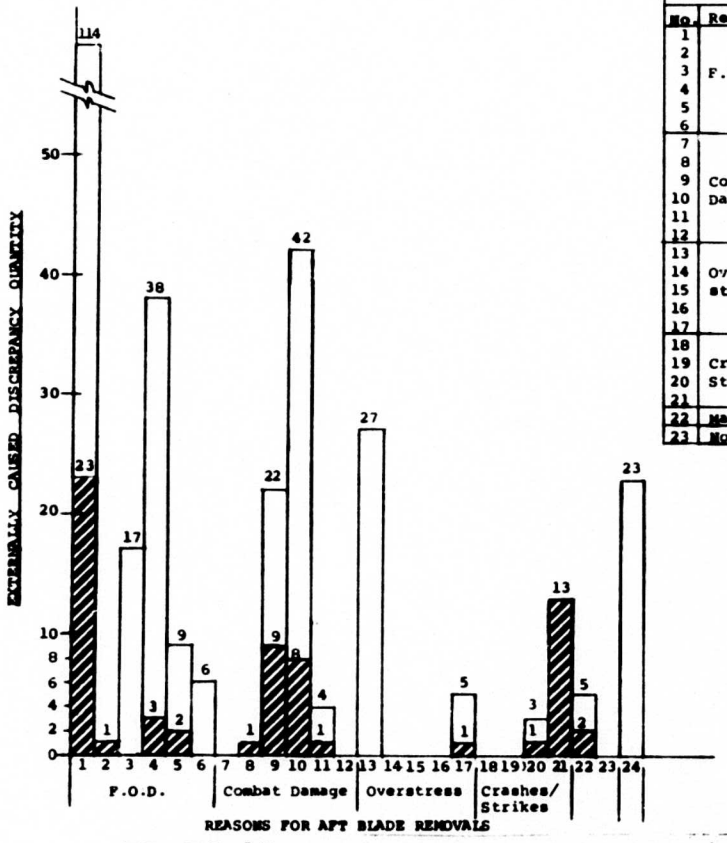


DISTRIBUTION PERCENTAGES

REMOVAL REASON			REPAIR BLADES		SCRAP BLADES			
Reason	No.	Discrep.	Blade Qty	% of Inher. Discr.	Blade Qty.	% of Inher. Discr.	Quantity of Removals	% of Total Removals
Deterioration	1	Loose/Missing						
	2	Bare Steel						
	3	Eroded	2	1.61			2	1.56
	4	Rippled						
	5	Water Migrate	2	1.61			2	1.56
Unbond	6	Bulged	26	20.97			26	20.31
	7	Blistered	39	31.45			39	30.47
	8	Bond Void	14	11.29			14	10.94
Excessive Vib.	9	Unable to adj	3	2.42			3	2.34
	10	Vibration	1	0.81			1	0.78
Eroded	11	Worn						
	12	Eroded	2	1.61	1	25.00	3	2.34
Corrosion	13	Corroded	17	13.71	3	75.00	20	15.63
	14	Peeling						
	15	Chipped						
	16	Stained						
	17	Seized						
	18	Water Migrate	1	0.81			1	0.78
	19	Pitted	1	0.81			1	0.78
De-laminated	20	Voided	9	7.26			9	7.03
	21	Crazed						
	22	Cracked	1	0.81			1	0.78
	23	Split						
Cracked	24	Creased						
	25	Crazed						
	26	Cracked	5	4.03			5	3.91
	27	Split						
Fretted	28	Worn						
	29	Fretted						
Imbalance	30	Tip Rod Loose	1	0.81			1	0.78
	31	Imbalance						
		TOTALS	124	100.00%	4	100.00%	128	100.00%

Repaired Blades
Scrapped Blades

FIGURE 17. INHERENT DISCREPANCY-CAUSED REMOVALS - AFT BLADES - CH-47 B/C.

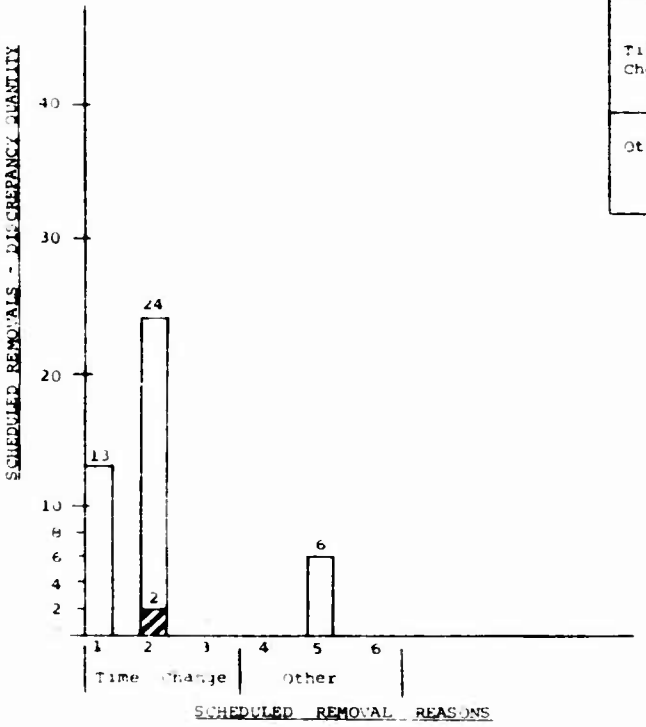


DISTRIBUTION PERCENTAGES

No.	REMOVAL REASON	Discrep.	REPAIRED BLADES Blade Qty.	REPAIRED BLADES % of External Discrep.	SCRAPPED BLADES Blade Qty.	SCRAPPED BLADES % of External Discrep.	Removal Quantity	% of Total Removals
1		Dented	91	34.34	23	35.38	114	34.55
2		Broken			1	1.54	1	0.30
3	F.O.D.	Torn	17	6.42			17	5.15
4		Punctured	35	13.21	3	4.62	38	11.51
5		Scored	7	2.64	2	3.08	9	2.73
6		Bent	6	2.26			6	1.82
7		Broken						
8		Scored			1	1.54	1	0.30
9	Combat	Dented	13	4.91	9	13.84	22	6.67
10	Damage	Punctured	34	12.83	8	12.30	42	12.73
11		Torn	3	1.13	1	1.54	4	1.21
12		Spar/Socket						
13		Overstress	27	10.19			27	8.18
14	Over-	Bent						
15	stress	Collapse						
16		Fractured						
17		Dented	4	1.51	1	1.54	5	1.52
18		Bent						
19	Crashes/	Collapse						
20	Strikes	Torn	2	0.75	1	1.54	3	0.91
21		Minor Damage			13	20.00	13	3.94
22	Manuf/Ship/Maint Error		3	1.13	2	3.08	5	1.52
23	No Valid Removal Reason		23	8.68			23	6.97
	TOTALS		265	100.00%	65	100.00%	330	100.00%

Repaired Blades
Scrapped Blades

FIGURE 18. EXTERNALLY-CAUSED DISCREPANCY REMOVALS - AFT BLADES - CH-47 B/C.



DISTRIBUTION PERCENTAGES

REMOVAL REASON			REPAIRED BLADES		SCRAPPED BLADES		Removal Quantity	% of Total Removals
Reason	No.	Discrep.	Blade Qty	% of Scheduled Removals	Blade Qty	% of Scheduled Removals		
	1	MWO Compliance	13	31.71			13	30.23
Time Change	2	No Defect (Scheduled Maintenance)	22	53.66	2	100.00	24	55.81
	3	Retired Blades						
	4	EIR Engr.Eval.						
Other	5	No Defect (to facilitate maint)	6	14.63			6	13.95
	6	Other						
TOTALS			41	100.00%	2	100.00%	43	100.00%

Repaired Blades

Scrapped Blades

FIGURE 19. SCHEDULED REMOVALS - AFT BLADES - CH-47 B/C.

TABLE XX. SUMMARY OF PERCENTAGES OF REMOVALS - CH-47B/C FORWARD AND AFT ROTOR BLADES

MAJOR DISCREPANCY REMOVAL REASON	FORWARD ROTOR BLADES *						AFT ROTOR BLADES +					
	Total - All Blades		Repaired Blades		Scrapped Blades		Total - All Blades		Repaired Blades		Scrapped Blades	
	Qty.	%	Qty.	%	Qty.	%	Qty.	%	Qty.	%	Qty.	%
Deterioration	2	0.39	2	0.39	0	0	4	0.80	4	0.80	0	0
Unbonded	65	12.69	64	12.50	1	0.19	79	15.77	79	15.77	0	0
Vibration	5	0.98	5	0.98	0	0	4	0.80	4	0.80	0	0
Erosion	12	2.34	11	2.15	1	0.19	3	0.60	2	0.40	1	0.20
Corrosion	38	7.42	37	7.23	1	0.19	22	4.39	19	3.79	3	0.60
Delaminated	17	3.32	16	3.13	1	0.19	10	2.00	10	2.00	0	0
Cracked	13	2.54	12	2.35	1	0.19	5	1.00	5	1.00	0	0
Fretted	1	0.19	1	0.19	0	0	0	0	0	0	0	0
Imbalance	3	0.59	3	0.59	0	0	1	0.20	1	0.20	0	0
F.O.D.	178	34.76	162	31.64	16	3.12	185	36.92	156	31.14	29	5.78
Combat Damage	79	15.43	51	9.96	28	5.47	69	13.77	50	9.98	19	3.79
Overstress	36	7.03	33	6.44	3	0.59	32	6.39	31	6.19	1	0.20
Crashes/Strikes	2	0.39	2	0.39	0	0	16	3.19	2	0.40	14	2.79
Error	6	1.18	3	0.59	3	0.59	5	1.00	3	0.60	2	0.40
No Valid Reason	16	3.12	16	3.12	0	0	23	4.59	23	4.59	0	0
Miscellaneous	0	0	0	0	0	0	0	0	0	0	0	0
Time Change	25	4.88	25	4.88	0	0	37	7.38	35	6.99	2	0.40
Other	14	2.74	14	2.74	0	0	6	1.20	6	1.19	0	0
TOTALS	512	100.00%	457	89.27	55	10.72	501	100.00%	430	85.84	71	14.16

* Percentages Based Upon A Total Of 512 Forward Blades
\+ Percentages Based Upon A Total of 501 Aft Blades

CH-47B/C Forward and Aft Blades Means Analysis

A series of evaluations of the CH-47B/C rotor blades for their average removal characteristics as based upon frequency of blade removal was accomplished. These calculations of the various removal means followed the approach outlined on pages 20 and 21. Results are given in blade hours.

Tables XXI, XXII and XXIII list the means determined for the major discrepant reasons for removal of the CH-47B/C forward rotor blades. Tables XXIV, XXV and XXVI list similar determinations accomplished for the CH-47B/C aft rotor blades.

Table XXVII presents a summary of the results of these analyses for both CH-47B/C forward and aft blades. This summary may be compared to the CH-47A blade summary shown by Table XVII, on page 40.

TABLE XXI. MEAN-TIME-BETWEEN-REMOVALS - FORWARD BLADES - CH-47 B/C

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	$MTBR_F$	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	$MTBR_F$	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	$MTBR_F$
Inherent Discrep.	151		5,922	5		178,867	156		5,733
Deterioration	2		447,169	--		--	2		447,169
Unbonded	64		13,974	1		894,339	65		13,759
Excessive Vibration	5		178,867	--		--	5		178,867
Erosion/Wear	11	894,339	81,304	1	894,339	894,339	12	894,339	74,528
Corroded	37		24,171	1		894,339	38		23,535
Delamination	16		55,896	1		894,339	17		52,608
Cracked	12		74,528	1		894,339	13		68,795
Fretted	1		894,339	--		--	1		894,339
Imbalance	3		298,113	--		--	3		298,113
Externally-Caused Discrep.	248		3,606	47		19,028	295		3,032
Foreign Object Damage	162		5,520	16		55,896	178		5,024
Combat Damage	51	894,339	17,536	28	894,339	31,941	79	894,339	11,321
Overstressed	33		27,101	3		298,113	36		24,843
Crashes/Strikes	2		447,169	--		--	2		447,169
No Valid Removal Reason	16	894,339	55,896	--	--	--	16	894,339	55,896
Error *	3	894,339	298,113	3	894,339	298,113	6	894,339	149,056
Scheduled Removals	39		22,932	--	--	--	39		22,932
Time Change	25	894,339	35,774	--	--	--	25	894,339	35,774
Other	14		63,881	--	--	--	14		63,881
All Causes	457	894,339	1,957	55	894,339	16,260	512	894,339	1,747

* Manufacturing/shipping/handling error including inadequate field repair

TABLE XXII. MEAN-TIME-TO-REMOVAL - FORWARD BLADES - CH-47 B/C

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Fwd.Bld. Flight Hours	$MTTR_F$	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	$MTTR_F$	Qty. of Blades Removed	Total Fwd.Bld. Flight Hours	$MTTR_F$
Inherent Discrep.	151	63,336	419	5	2,186	437	156	65,522	420
Deterioration	2	999	499	--	--	--	2	999	499
Unbonded	64	23,923	374	1	445	445	65	24,368	375
Excessive Vibration	5	1,852	370	--	--	--	5	1,852	370
Erosion/Wear	11	6,038	549	1	221	221	12	6,259	522
Corroded	37	18,451	498	1	835	835	38	19,266	507
Delamination	16	5,941	371	1	349	349	17	6,290	370
Cracked	12	4,739	395	1	336	336	13	5,075	390
Fretted	1	500	500	--	--	--	1	500	500
Imbalance	3	913	304	--	--	--	3	913	304
Externally-Caused Discrep.	248	93,926	379	47	18,423	392	295	112,349	381
Foreign Object Damage	162	63,888	394	16	8,692	543	178	72,580	408
Combat Damage	51	19,497	382	28	9,220	329	79	28,717	364
Overstressed	33	9,346	283	3	511	170	36	9,857	274
Crashes/Strikes	2	1,195	597	--	--	--	2	1,195	597
No Valid Removal Reason	16	4,916	307	--	--	--	16	4,916	307
Error*	3	262	87	3	1,874	624	6	2,136	356
Scheduled Removals	39	17,852	458	--	--	--	39	17,852	458
Time Change	25	13,396	536	--	--	--	25	13,396	536
Other	14	4,456	318	--	--	--	14	4,456	318
All Causes	457	180,292	395	55	22,483	409	512	202,775	396

* Manufacturing/shipping/handling error including inadequate field repair.

TABLE XXIII. MEAN-TIME-BETWEEN-UNSCHEDULED-REMOVALS - FORWARD BLADES - CH-47 B/C

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	$MTBUR_F$	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	$MTBUR_F$	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	$MTBUR_F$
Inherent Discrep.	151		5,922	5		178,867	156		5,733
Deterioration	2		447,169	--		--	2		447,169
Unbonded	64		13,974	1		894,339	65		13,759
Excessive Vibration	5		178,867	--		--	5		178,867
Erosion/Wear	11	894,339	81,304	1	894,339	894,339	12	894,339	74,528
Corroded	37		24,171	1		894,339	38		23,535
Delamination	16		55,896	1		894,339	17		52,608
Cracked	12		74,528	1		894,339	13		68,795
Fretted	1		894,339	--		--	1		894,339
Imbalance	3		298,113	--		--	3		298,113
Externally-Caused Discrep.	248		3,606	47		19,028	295		3,032
Foreign Object Damage	162	894,339	5,520	16	894,339	55,896	178	894,339	5,024
Combat Damage	51		17,536	28		31,941	79		11,321
Overstressed	33		27,101	3		298,113	36		24,843
Crashes/Strikes	2		447,169	--		--	2		447,169
No Valid Removal Reason	16	894,339	55,896	--	--	--	16	894,339	55,896
Error *	3	894,339	298,113	3	894,339	298,113	6	894,339	149,056
All Causes	418	894,339	2,140	55	894,339	16,260	473	894,339	1,891

* Manufacturing/shipping/maintenance/handling error including inadequate field repair.

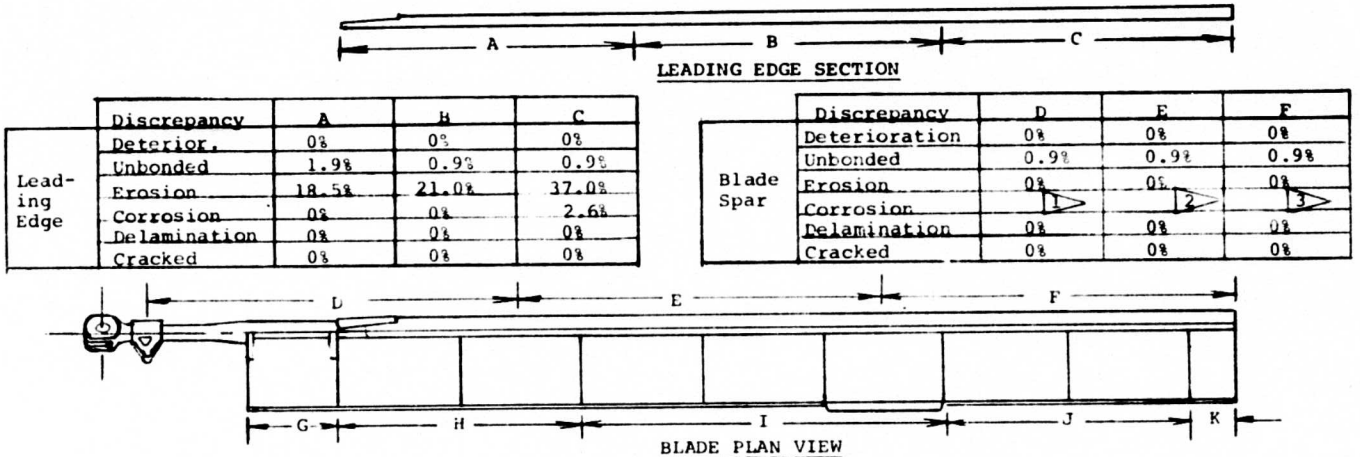
Discrepancy Locations Versus Types of Discrepancies

Data included herein has been based upon 'Reasons for Removal' only.

This investigation simplified the amount of data handled by confining the results to major discrepancy locations versus types of inherent discrepancies and to externally-caused discrepancies only.

Figures 20 and 21 demonstrate the results of analyses for inherent and externally-caused discrepancies of the forward blades.

Figures 22 and 23 demonstrate the results of analyses for inherent and externally-caused discrepancies of the aft blades.



	Discrepancy	A	B	C
Leading Edge	Deterior.	0%	0%	0%
	Unbonded	1.9%	0.9%	0.9%
	Erosion	18.5%	21.0%	37.0%
	Corrosion	0%	0%	2.6%
	Delamination	0%	0%	0%
	Cracked	0%	0%	0%

	Discrepancy	D	E	F
Blade Spar	Deterioration	0%	0%	0%
	Unbonded	0.9%	0.9%	0.9%
	Erosion	0%	0%	0%
	Corrosion			
	Delamination	0%	0%	0%
	Cracked	0%	0%	0%

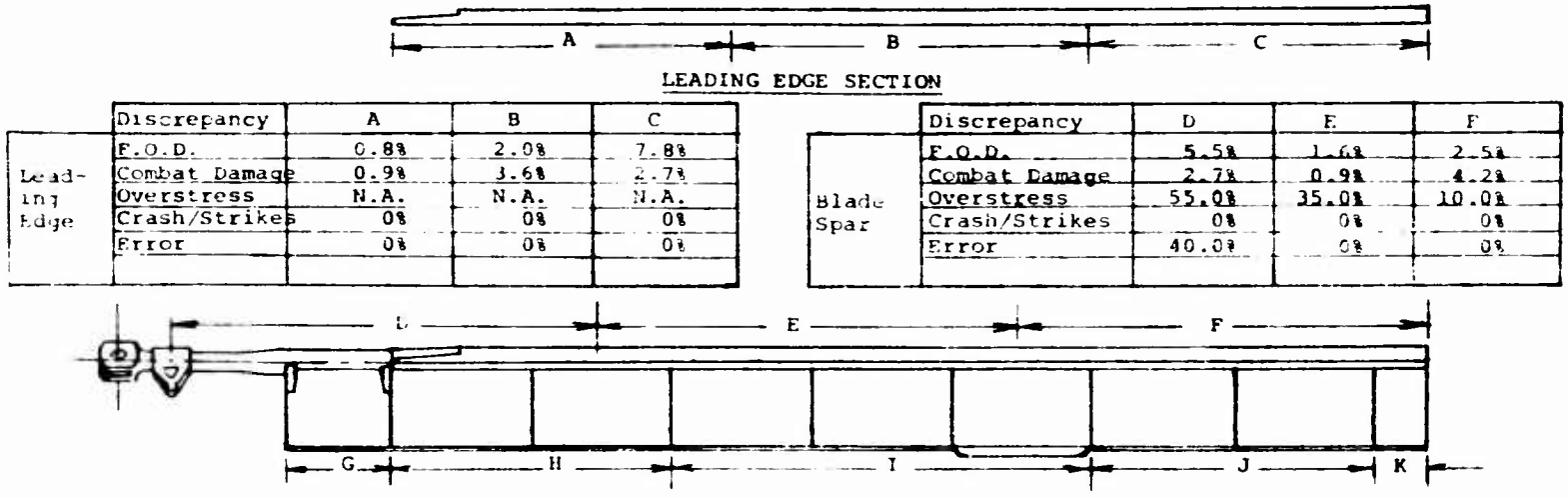
	Discrepancy	G	H	I	J	K
Upper Box Surface	Deterioration	0%	0%	0%	0%	0%
	Unbonded	5%	7%	30%	5.0%	4.3%
	Erosion	0%	0%	0%	0%	0%
	Corrosion	0.6%	0.8%	2.6%	2.8%	2.5%
	Delamination	7.6%	9.4%	16.6%	10.3%	10.5%
	Cracked	6.2%	6.3%	25.0%	9.3%	9.4%

	Discrepancy	L	M	N
Trailing Edge	Deterioration	0%	0%	0%
	Unbonded	0%	0%	0.9%
	Erosion	0%	0%	1.0%
	Corrosion	0%	0%	0%
	Delamination	1%	2%	1%
	Cracked	0%	0%	0%

	Discrepancy	O	P	Q	R	S
Lower Box Surface	Deterioration	15.0%	18.3%	33.3%	15.0%	18.3%
	Unbonded	3.4%	4.2%	23.4%	5.0%	5.3%
	Erosion	0%	2.0%	3.7%	7.2%	9.6%
	Corrosion	0.6%	0.8%	2.6%	3.5%	4.5%
	Delamination	4.1%	4.2%	20.8%	6.2%	6.3%
	Cracked	9.3%	9.4%	6.4%	9.3%	9.4%

1 Interior = 21.0%, exterior = 8.0%
2 Interior = 21.0%, exterior = 1.8%
3 Interior = 23.0%, exterior = 1.3%

FIGURE 20. INHERENT DISCREPANCY LOCATIONS - FORWARD BLADES - CH-47B/C.



	Discrepancy	A	B	C
Leading Edge	F.O.D.	0.8%	2.0%	7.8%
	Combat Damage	0.9%	3.6%	2.7%
	Overstress	N.A.	N.A.	N.A.
	Crash/Strikes	0%	0%	0%
	Error	0%	0%	0%

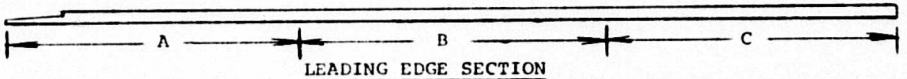
	Discrepancy	D	E	F
Blade Spar	F.O.D.	5.5%	1.6%	2.5%
	Combat Damage	2.7%	0.9%	4.2%
	Overstress	55.0%	35.0%	10.0%
	Crash/Strikes	0%	0%	0%
	Error	40.0%	0%	0%

	Discrepancy	G	H	I	J	K
Upper Box Section	F.O.D.	0.6%	1.4%	16.5%	5.1%	5.6%
	Combat Damage	1.0%	5.6%	21.0%	1.7%	1.9%
	Overstress	N.A.	N.A.	N.A.	N.A.	N.A.
	Crash/Strikes	0%	0%	50.0%	0%	0%
	Error	0%	0%	0%	8.0%	12.0%

	Discrepancy	L	M	N
Trailing Edge	F.O.D.	0%	0.4%	4.1%
	Combat Damage	0%	0%	0.9%
	Overstress	N.A.	N.A.	N.A.
	Crash/Strikes	0%	0%	50.0%
	Error	0%	0%	0%

	Discrepancy	O	P	Q	R	S
Lower Box Section	F.O.D.	0.9%	2.4%	25.5%	10.5%	6.8%
	Combat Damage	4.5%	12.0%	27.2%	4.0%	4.2%
	Overstress	N.A.	N.A.	N.A.	N.A.	N.A.
	Crash/Strikes	0%	0%	0%	0%	0%
	Error	0%	0%	0%	15.0%	25.0%

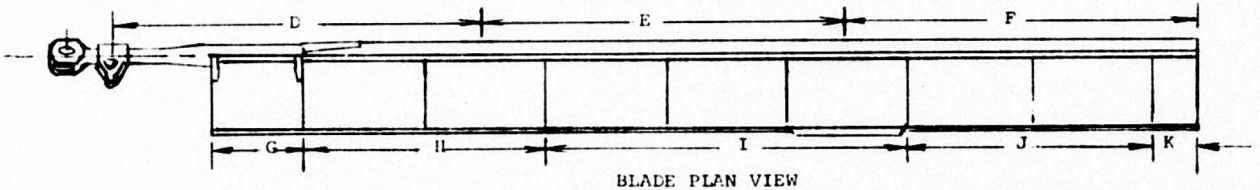
FIGURE 21. EXTERNALLY-CAUSED DISCREPANCY LOCATIONS - FORWARD BLADES - CH-47 B/C.



LEADING EDGE SECTION

	Discrepancy	A	B	C
Leading Edge	Deterioration	12.5%	12.5%	12.5%
	Unbonded	0%	0.8%	0%
	Erosion	20.0%	20.0%	20.0%
	Corrosion	0%	0%	0%
	Delamination	0%	0%	0%
	Cracked	0%	0%	0%

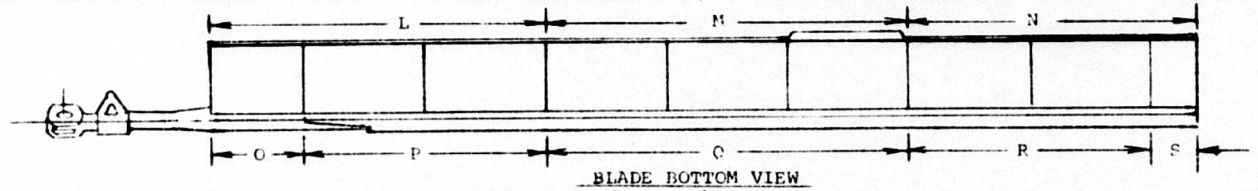
	Discrepancy	D	E	F
Blade Spar	Deterioration	0%	0%	0%
	Unbonded	0%	0%	0%
	Erosion	0%	0%	0%
	Corrosion	33.3%	23.8%	21.4%
	Delamination	7.1%	7.1%	7.1%
	Cracked	0%	0%	0%



BLADE PLAN VIEW

	Discrepancy	G	H	I	J	K
Upper Box Surface	Deterioration	5.0%	5.0%	5.0%	5.0%	5.0%
	Unbonded	2.2%	8.1%	26.4%	4.4%	6.7%
	Erosion	0%	0%	0%	0%	0%
	Corrosion	1.0%	3.7%	4.7%	0%	0%
	Delamination	0%	0%	14.2%	6.6%	7.5%
	Cracked	0%	0%	33.3%	13.3%	20.0%

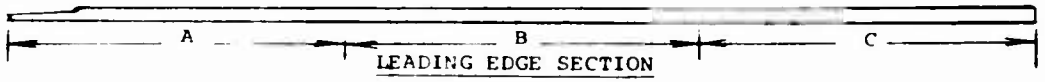
	Discrepancy	L	M	N
Trailing Edge	Deterioration	1%	0%	0%
	Unbonded	1%	2%	1%
	Erosion	0%	0%	0%
	Corrosion	0%	0%	0%
	Delamination	0%	0%	0%
	Cracked	0%	0%	0%



BLADE BOTTOM VIEW

	Discrepancy	O	P	Q	R	S
Lower Box Surface	Deterioration	3.0%	8.5%	10%	7.0%	8.0%
	Unbonded	5.0%	7.6%	20.5%	6.0%	8.3%
	Erosion	0%	0%	20.0%	10.0%	10.0%
	Corrosion	1.5%	3.7%	4.7%	0.8%	1.4%
	Delamination	1.8%	5.5%	28.5%	5.6%	8.6%
	Cracked	0%	0.2%	16.6%	6.6%	10.0%

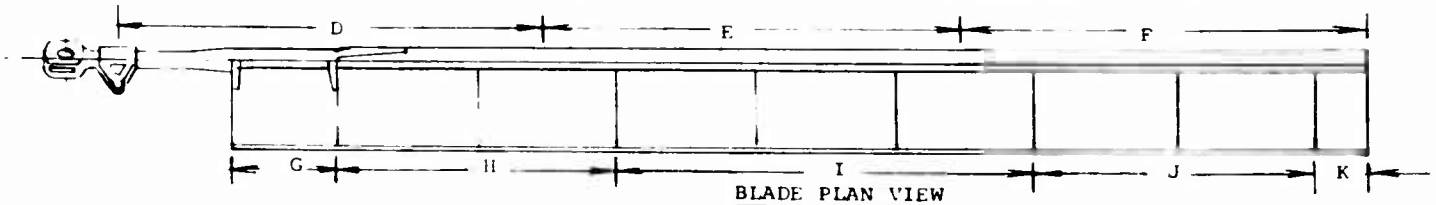
FIGURE 22. INHERENT DISCREPANCY LOCATIONS - AFT BLADES - CH-47 B/C.



LEADING EDGE SECTION

	Discrepancy	A	B	C
Leading Edge	F.O.D.	1.9%	6.0%	12.5%
	Combat Damage	2.0%	5.2%	3.0%
	Overstress	N.A.	N.A.	N.A.
	Crash/Strike	0%	0%	12.5%
	Error	0%	0%	0%

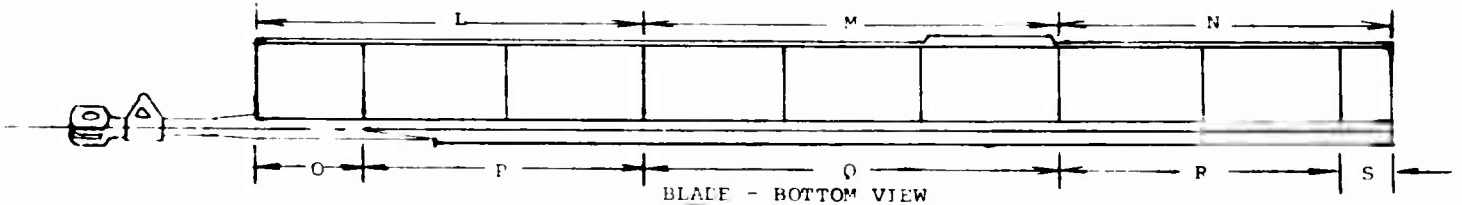
	Discrepancy	D	E	F
Blade Spar	F.O.D.	1.5%	2.5%	6.0%
	Combat Damage	0%	7.0%	10.0%
	Overstress	60.0%	30.0%	10.0%
	Crash/Strike	0%	0%	0%
	Error	25.0%	16.6%	16.6%



BLADE PLAN VIEW

	Discrepancy	G	H	I	J	K
Upper Box Section	F.O.D.	1.0%	1.5%	9.0%	10.0%	11.0%
	Combat Damage	4.0%	5.0%	18.0%	2.0%	3.0%
	Overstress	N.A.	N.A.	N.A.	N.A.	N.A.
	Crash/Strike	6.0%	6.5%	12.5%	0%	0%
	Error	3.4%	5.0%	8.4%	0%	0%

	Discrepancy	L	M	N
Trailing Edge	F.O.D.	0%	0%	0%
	Combat Damage	0%	4.0%	0%
	Overstress	N.A.	N.A.	N.A.
	Crash/Strike	0%	0%	0%
	Error	0%	0%	0%



BLADE - BOTTOM VIEW

	Discrepancy	O	P	Q	R	S
Lower Box Section	F.O.D.	3.0%	4.0%	13.0%	8.0%	9.0%
	Combat Damage	6.0%	7.0%	18.3%	2.5%	3.0%
	Overstress	N.A.	N.A.	N.A.	N.A.	N.A.
	Crash/Strike	6.0%	6.5%	25.0%	12.0%	13.0%
	Error	3.4%	5.0%	16.0%	0.6%	0%

N.A = Not Applicable

Figure 23. EXTERNALLY-CAUSED DISCREPANCY LOCATIONS - AFT BLADES - CH-47B/C.

TABLE XXIV. MEAN-TIME-BETWEEN-REMOVALS - AFT BLADES - CH-47 B/C

REASONS FOR REMOVALS	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Aft Bld. Flight Hours	$MTBR_A$	Qty. of Blades Removed	Total Aft Bld. Flight Hours	$MTBR_A$	Qty. of Blades Removed	Total Aft Bld. Flight Hours	$MTBR_A$
Inherent Discrep.	124		7,128	4		220,956	128		6,905
Deterioration	4		220,956	--		--	4		220,956
Unbonded	79		11,188	--		--	79		11,188
Excessive Vibration	4		220,956	--		--	4		220,956
Erosion/Wear	2	883,824	441,912	1	883,824	883,824	3	883,824	294,608
Corroded	19		46,517	3		294,608	22		40,174
Delamination	10		88,382	--		--	10		88,382
Cracked	5		176,765	--		--	5		176,765
Fretted	--		--	--		--	--		--
Imbalance	1		883,824	--		--	1		883,824
Externally-Caused Discrep.	239		3,698	63		14,029	302		2,92[illegible]
Foreign Object Damage	156		5,666	29		30,477	185		4,77[illegible]
Combat Damage	50	883,824	17,676	19	883,824	46,517	69	883,824	12,80[illegible]
Overstressed	31		28,510	1		883,824	32		27,619
Crashes/Strikes	2		441,912	14		63,130	16		[illegible],23[illegible]
No Valid Removal Reason	23	883,824	38,427	--	--	--	23	883,824	38,427
Error *	3	883,824	294,608	2	883,824	441,912	5	883,824	176,765
Scheduled Removals	41		21,557	2		441,912	43		20,55[illegible]
Time Change	35	883,824	25,252	2	883,824	441,912	37	883,824	23,88[illegible]
Other	6		147,304	--		--	6		147,304
All Causes	430	883,824	2,055	71	883,824	12,448	501	883,824	1,764

* Manufacturing/shipping/handling error including inadequate field repair

TABLE XXV. MEAN-TIME-TO-REMOVAL - AFT BLADES - CH-47 B/C

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Aft Bld. Flight Hours	$MTTR_A$	Qty. of Blades Removed	Total Aft Bld. Flight Hours	$MTTR_A$	Qty. of Blades Removed	Total Aft Bld. Flight Hours	$MTTR_A$
Inherent Discrep.	124	50,713	409	4	2,401	600	128	53,114	415
Deterioration	4	1,421	355	--	--	--	4	1,421	355
Unbonded	79	30,954	392	--	--	--	79	30,954	392
Excessive Vibration	4	1,863	466	--	--	--	4	1,863	466
Erosion/Wear	2	366	183	1	391	391	3	757	252
Corroded	19	11,428	601	3	2,010	670	22	13,438	611
Delamination	10	2,230	223	--	--	--	10	2,230	223
Cracked	5	1,909	381	--	--	--	5	1,909	381
Fretted	--	--	--	--	--	--	--	--	--
Imbalance	1	542	542	--	--	--	1	542	542
Externally-Caused Discrep.	239	82,526	345	63	20,876	331	302	103,402	342
Foreign Object Damage	156	59,420	381	29	11,513	397	185	70,433	383
Combat Damage	50	16,092	322	19	8,223	433	69	24,315	352
Overstressed	31	6,609	213	1	316	316	32	6,425	316
Crashes/Strikes	2	405	202	14	824	59	16	1,229	77
No Valid Removal Reason	23	7,474	325	--	--	--	23	7,474	325
Error *	3	244	81	2	554	277	5	798	160
Scheduled Removals	41	18,801	459	2	1,478	739	43	20,279	472
Time Change	35	15,964	456	2	1,478	739	37	17,442	471
Other	6	2,837	473	--	--	--	6	2,837	473
All Causes	430	159,758	372	71	25,309	356	501	185,067	369

* Manufacturing/shipping/handling error including inadequate field repair

TABLE XXVI. MEAN-TIME-BETWEEN-UNSCHEDULED-REMOVALS - AFT BLADES - CH-47 B/C

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Aft Bld. Flight Hours	$MTBUR_A$	Qty. of Blades Removed	Total Aft Bld. Flight Hours	$MTBUR_A$	Qty. of Blades Removed	Total Aft Bld. Flight Hours	$MTBUR_A$
Inherent Discrep.	124		7,128	4		220,956	128		6,905
Deterioration	4		220,956	--		--	4		220,956
Unbonded	79		11,188	--		--	79		11,188
Excessive Vibration	4		220,956	--		--	4		220,956
Erosion/Wear	2	883,824	441,912	1	883,824	883,824	3	883,824	294,608
Corroded	19		46,517	3		294,608	22		40,174
Delamination	10		88,382	--		--	10		88,382
Cracked	5		176,765	--		--	5		176,765
Fretted	--		--	--		--	--		--
Imbalance	1		883,824	--		--	1		883,824
Externally-Caused Discrep.	239		3,698	63		14,029	302		2,927
Foreign Object Damage	156	883,824	5,666	29	883,824	30,477	185	883,824	4,777
Combat Damage	50		17,676	19		46,517	69		12,809
Overstressed	31		28,510	1		883,824	32		27,619
Crashes/Strikes	2		441,912	14		63,130	16		55,239
No Valid Removal Reason	23	883,824	38,427	--	883,824	--	23	883,824	38,427
Error *	3	883,824	294,608	2	883,824	441,912	5	883,824	176,765
All Causes	389	883,824	2,272	69	883,824	12,809	458	883,824	1,930

* Manufacturing/shipping/handling error including inadequate field repair

TABLE XXVII. SUMMARY OF CH-47B/C FORWARD AND AFT BLADE MEANS

BLADE			COMBINED VALUES	INHERENT DISCREPANCY	EXTERNALLY CAUSED DISCREPANCY	ERROR CAUSED DISCREPANCY	SCHEDULED REMOVALS	NO VALID REMOVAL REASON
FORWARD BLADES	$MTBR_F$	Repaired	1,957	5,922	3,606	298,113	22,932	55,896
		Scrapped	16,070	178,867	19,028	298.113	--	--
		Total	1,747	5,733	3,032	149,056	22,932	55,896
	$MTTR_F$	Repaired	390	419	379	87	458	307
		Scrapped	409	437	392	624	--	--
		Total	396	420	381	356	458	307
	$MTBUR_F$	Repaired	2,140	5,922	3,606	298.113	N.A.	55,896
		Scrapped	16,070	178,867	19,028	298.113	N.A.	--
		Total	1,891	5,733	3,032	149,056	N.A.	55,896
AFT BLADES	$MTBR_A$	Repaired	2,055	7,128	3,698	294,608	21,557	38,427
		Scrapped	12,448	220,956	14,029	441,912	441,912	--
		Total	1,764	6,905	2,927	176,765	20,554	38,427
	$MTTR_A$	Repaired	372	409	345	81	459	325
		Scrapped	356	600	331	277	739	--
		Total	369	415	342	160	472	325
	$MTBUR_A$	Repaired	2,272	7,128	3,698	294,608	N.A.	38,427
		Scrapped	12,809	220,956	14,029	441,912	N.A.	--
		Total	1,930	6,905	2,927	176,765	N.A.	38,427

N.A. - Not Applicable
MTBR - Mean-Time-Between Removals
MTTR - Mean-Time-To-Removal
MTBUR - Mean-Time-Between-Unscheduled-Removals

CH-47 BLADE SCRAPPAGE ANALYSES

This section of the report includes analyses of the scrappage of the forward and aft rotor blades for both CH-47A and CH-47B/C helicopters.

Analyses concern the following:

a. Major percentages of blades scrapped

b. Quantity of blades scrapped vs. actual reasons for scrappage

c. Blade teardown experience

d. Mean-Time-to-Scrappage

The following helicopter blade scrappage analyses have been based upon the known reasons for blade scrappage, not upon reasons for blade removal. Certain blades were removed for reasons other than any known spar damage in the field and returned for inspection and overhaul. Subsequent repair action uncovered spar damage. However, other blades were scrapped, either in the field or immediately upon return inspection without any rework action attempted. In these cases where the reason for scrappage was not given in Boeing-Vertol records, the reason for blade removal was used as the scrappage reason. It may be assumed that reasons for removal may be a good indicator of the reasons for scrappage of blades in the field. Field scrappage reasons and data are not accessible to Boeing-Vertol except through Field Service Representative reports.

Tables XXVIII and XXIX summarize the scrapped blade status for the most frequently occurring causes for scrappage. Table XXVIII concerns the forward blades and Table XXIX concerns the aft blades.

Table XXX, page 77, summarizes the percentages of blade scrappage for CH-47A and CH-47B/C forward and aft blades in terms of reasons for blade scrappage.

TABLE XXVIII. PERCENTAGES OF FORWARD BLADE SCRAPPAGE - CH-47A AND CH-47B/C

CH-47A FWD BLADES			CH-47B/C FWD BLADES		
SCRAP DISCREPANCY/ REMOVAL CAUSE	QTY. BLADES	PERCENT OF TOTAL*	SCRAP DISCREPANCY/ REMOVAL CAUSE	QTY. BLADES	PERCENT OF TOTAL +
Dented - F.O.D.	54	7.86	Dented - F.O.D.	15	11.91
Overstressed	44	6.40	Dented - Combat Damage	14	11.12
Punctured - Combat Damage	26	3.78	Punctured - Combat Damage	10	7.94
Dented-Combat Damage	20	2.91	Scored - F.O.D.	3	2.38
Minor Damage-Crashes	10	1.46	Dented - Crash Damage	3	2.38
Collapsed-Crashes	8	1.16	Overstressed	3	2.38
Corroded	8	1.16	Punctured - F.O.D.	2	1.59
Punctured - F.O.D.	4	.58	Torn - Combat Damage	1	.79
Retired	4	.58	Torn - Crash Damage	1	.79
Mishandled - Error	3	.44	Shop Error	1	.79
Shop Error	2	.29	Arc Burn - Error	1	.79
Arc Burn - Error	2	.29	Corroded	1	.79
Scheduled Maint.	2	.29	TOTALS:	55	43.65%
Scored - F.O.D.	2	.29			
Spar/Socket-Combat Damage	1	.15			
Bent-Crash Damage	1	.15			
Torn-Crash Damage	1	.15			
Cracked	1	.15			
Unbonded	1	.15			
TOTALS:	194	28.24%			

* Based upon 687 CH-47A forward and aft scrapped blades. See Table XXIX.

\+ Based upon 126 CH-47B/C forward and aft scrapped blades. See Table XXIX.

TABLE XXIX. PERCENTAGES OF AFT BLADE SCRAPPAGE - CH-47A AND CH-47B/C

CH-47A AFT BLADES			CH-47B/C AFT BLADES		
SCRAP DISCREPANCY/ REMOVAL CAUSE	QTY. BLADES	PERCENT OF TOTAL*	SCRAP DISCREPANCY/ REMOVAL CAUSE	QTY. BLADES	PERCENT OF TOTAL+
Overstressed	217	31.59	Dented - F.O.D.	23	18.26
Dented - F.O.D.	93	13.54	Dented - Crash Damage	13	10.32
Scheduled Maint.	44	6.40	Dented - Combat Damage	9	7.14
Punctured - Combat Damage	31	4.51	Punctured-Combat Damage	8	6.35
Retired	30	4.36	Overstressed	4	3.18
Punctured - F.O.D.	15	2.18	Punctured-F.O.D.	3	2.38
Dented-Combat Damage	15	2.18	Corroded	3	2.38
Corroded	7	1.02	Scored - F.O.D.	2	1.59
Torn-Crash Damage	6	.87	Mishandled-Error	2	1.59
Unbonded	6	.87	Broken - F.O.D.	1	.79
Broken - F.O.D.	4	.58	Scored - Combat Damage	1	.79
Torn - F.O.D.	4	.58	Torn-Combat Damage	1	.79
Minor Crash Damage	4	.58	Torn-Crash Damage	1	.79
Bent - F.O.D.	3	.44	TOTALS:	71	56.35%
Arc Burn - Error	3	.44			
Cracked	3	.44			
Scored - F.O.D.	2	.29			
Broken-Combat Damage	2	.29			
Bent-Crash Damage	1	.15			
Collapsed-Crash Damage	1	.15			
Mishandled-Error	1	.15			
Shop Error	1	.15			
TOTALS:	493	71.76%			

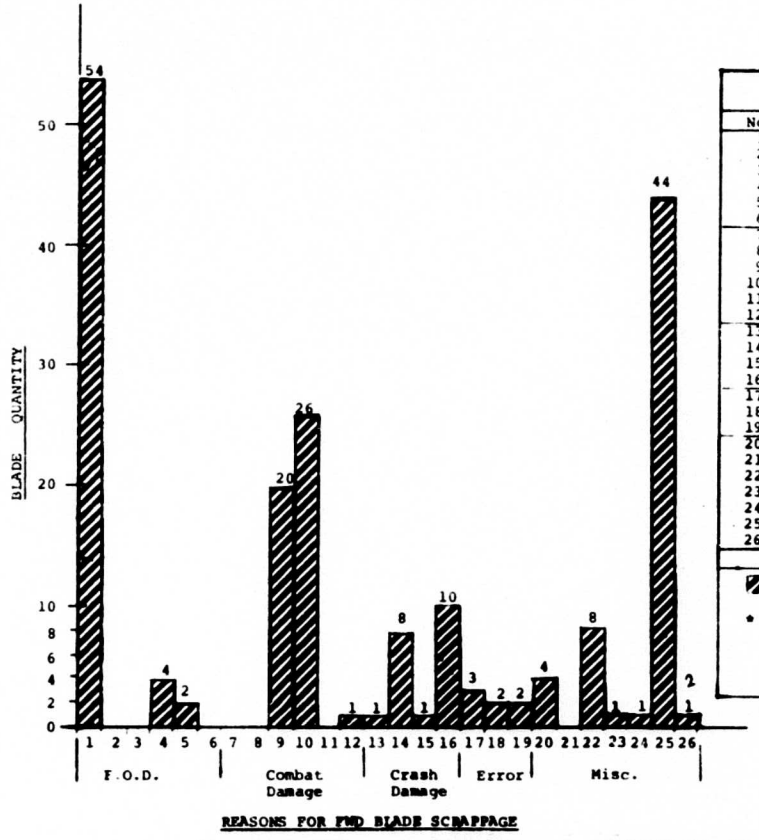
* Based upon 687 CH-47A forward and aft scrapped blades. See Table XXVIII.

\+ Based upon 126 CH-47 B/C forward and aft scrapped blades. See Table XXVIII

The distribution of the percentage of CH-47B/C forward and aft rotor blades that have been scrapped for known causes, either internal or external, is shown in Figures 24, 25, 26 and 27.

Prior to a decision as to the extent of blade damage (including spar damage), the blades may require either a partial or a complete teardown during their repair in Boeing-Vertol shops. A partial teardown consists of the replacement of all blade boxes, the trailing edge and the trim tab. The complete teardown consists of the replacement of all the blade boxes, the trailing edge, the trim tab, and the nose cap, plus any miscellaneous parts, as required. Figure 28 has been provided to indicate the quantity of blades that required either partial or complete teardown versus those blades found unsatisfactory as a result of teardown and therefore scrapped.

Calculation results of mean-time-between-scrappage of forward and aft blades for the CH-47A blades are shown in Table XXXI and for the CH-47B/C in Table XXXII. Table XXXIII summarizes all scrapped blade means.



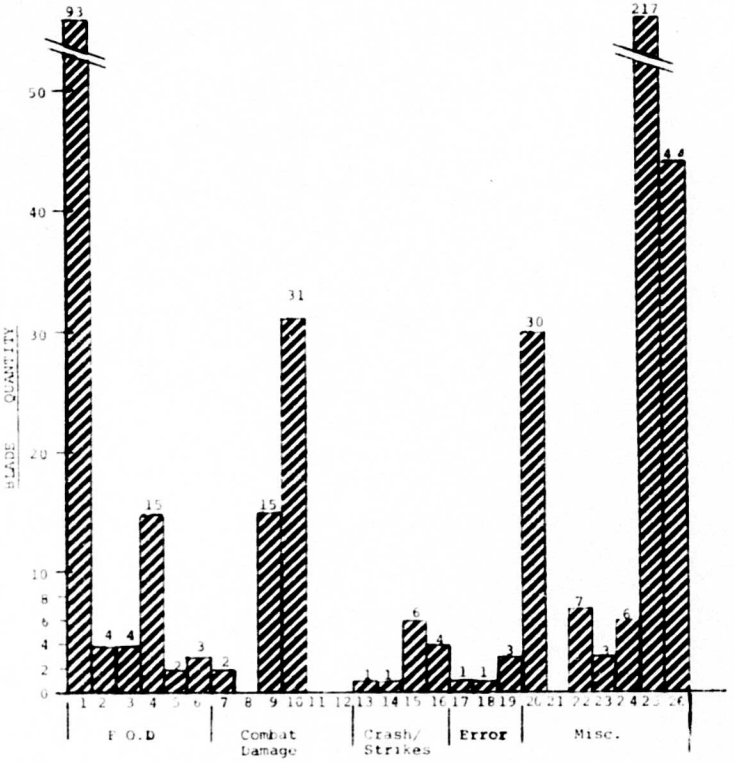
DISTRIBUTION PERCENTAGES

SCRAPPAGE REASONS			BLADE QTY.	% OF TOTAL SCRAPPAGE
No.	Reason	Discrepancy		
1	F.O.D.	Dented	54	27.84
2		Broken	--	--
3		Torn	--	--
4		Punctured	4	2.06
5		Scored	2	1.03
6		Bent	--	--
7	Combat Damage	Broken	--	--
8		Scored	--	--
9		Dented	20	10.31
10		Punctured	26	13.40
11		Torn	--	--
12		Spar/Socket	1	.52
13	Crash Damage	Bent	1	.52
14		Collapsed	8	4.12
15		Torn	1	.52
16		Minor Damage	10	5.15
17	Error*	Mishandled	3	1.55
18		Shop Error	2	1.03
19		Arc Burn	2	1.03
20	Misc.	Reached L.L.	4	2.06
21		Deterioration	--	--
22		Corroded	8	4.12
23		Cracked	1	.52
24		Unbonded	1	.52
25		Overstressed	44	22.68
26		Sch. Removal	2	1.03
		TOTAL	194	100.00%

Scrapped Blades

* Manufacturing/Shipping Handling Error Including Inadequate Field Repair

FIGURE 24. SCRAPPAGE - FORWARD BLADES - CH-47A.

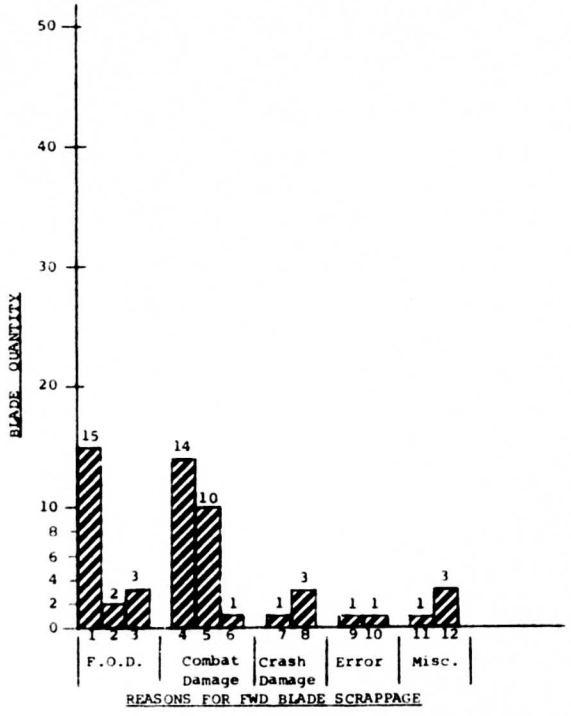


SCRAPPAGE REASONS NO.	REASON	DISCREPANCY	BLADE QTY.	DISTRIBUTION PERCENTAGE % OF TOTAL SCRAPPAGE
1	F.O.D.	Dented	93	18.86
2		Broken	4	0.81
3		Torn	4	0.81
4		Punctured	15	3.04
5		Scored	2	0.41
6		Bent	3	0.61
7	Combat Damage	Broken	2	0.41
8		Scored	0	0
9		Dented	15	3.04
10		Punctured	31	6.28
11		Torn	0	0
12		Spar/Socket	0	0
13	Crash/ Strikes	Bent	1	0.22
14		Collapsed	1	0.22
15		Torn	6	1.22
16		Minor Damage	4	0.81
17	Error*	Mishandled	1	0.22
18		Shop Error	1	0.22
19		Arc Burn	3	0.61
20	Misc.	Reached LL	30	6.09
21		Deterioration	0	0
22		Corroded	7	1.42
23		Cracked	3	0.61
24		Unbonded	6	1.22
25		Overstressed	217	44.02
26		Sch. Removal	44	8.92
		TOTAL	493	100.00%

Scrapped Blades

* Manufacturing/Shipping Handling Error Including Inadequate Field Repair

FIGURE 25. SCRAPPAGE - AFT BLADES - CH-47A.



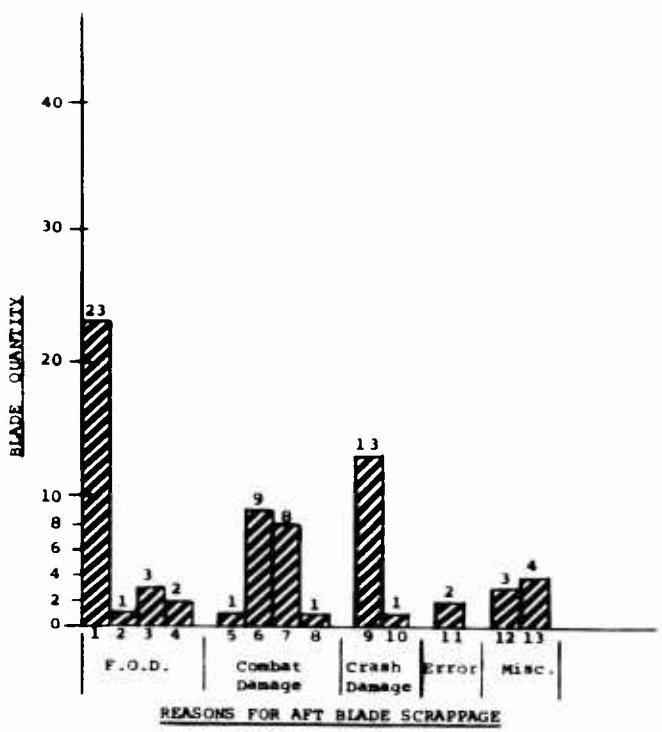
DISTRIBUTION PERCENTAGES

SCRAPPAGE REASON			Blade Qty.	% of Total Scrappage
No.	Reason	Discrep.		
1	F.O.D.	Dented	15	27.3
2		Punctured	2	3.6
3		Scored	3	5.5
4	Combat Damage	Dented	14	25.4
5		Punctured	10	18.2
6		Torn	1	1.8
7	Crash Damage	Torn	1	1.8
8		Dented	3	5.5
9	Error	Shop Error	1	1.8
10		Arc Burn	1	1.8
11	Misc.	Corroded	1	1.8
12		Overstressed	3	5.5
		TOTALS	55	100.0%

▨ Scrapped Blades

• Manufacturing/Shipping/ Handling Error Including Inadequate Field Repair

FIGURE 26. SCRAPPAGE - FORWARD BLADES - CH-47B/C.



DISTRIBUTION PERCENTAGES

SCRAPPAGE REASON			Blade Qty.	% of Total Scrappage
No.	Reason	Discrep.		
1	F.O.D.	Dented	23	32.4
2		Broken	1	1.4
3		Punctured	3	4.2
4		Scored	2	2.8
5	Combat Damage	Scored	1	1.4
6		Dented	9	12.7
7		Punctured	8	11.3
8		Torn	1	1.4
9	Crash Damage	Dented	13	18.3
10		Torn	1	1.4
11	Error	Mishandled	2	2.8
12	Misc.	Corroded	3	4.2
13		Overstressed	4	5.6
		TOTALS	71	100.0%

▨ Scrapped Blades

* Manufacturing/Shipping/ Handling Error Including Inadequate Field Repair

FIGURE 27. SCRAPPAGE - AFT BLADES - CH-47B/C.

TABLE XXX. SUMMARY OF PERCENTAGES OF BLADE SCRAPPAGE - CH-47A AND CH-47B/C FORWARD AND AFT BLADES

REASONS FOR SCRAP	FORWARD SCRAPPED BLADES		AFT SCRAPPED BLADES	
	Quantity	Percentage	Quantity	Percentage
Foreign Object Damage	60	30.9	121	24.5
Dented	54	27.8	93	18.9
Broken			4	0.8
Torn	4	2.1	4	0.8
Punctured			15	3.0
Scored	2	1.0	2	0.4
Bent			3	0.6
Combat Damage	47	24.2	48	9.7
Broken			2	0.4
Scored				
Dented	20	10.3	15	3.0
Punctured	26	13.4	31	6.4
Torn				
Spar/Socket	1	0.5		
Crash/Strikes	20	10.3	12	2.4
Bent	1	0.5	1	0.2
Collapsed	8	4.1	1	0.2
Torn	1	0.5	6	1.2
Minor Damage	10	5.2	4	0.8
Error	7	3.6	5	1.0
Mishandled	3	1.6	1	0.2
Shop Error	2	1.0	1	0.2
Arc Burn	2	1.0	3	0.6
Miscellaneous	60	30.9	307	62.3
Reached Life Limit	4	2.1	30	6.1
Deterioration				
Corroded	8	4.1	7	1.4
Cracked	1	0.5	3	0.6
Unbonded	1	0.5	6	1.2
Overstressed	44	22.7	217	44.0
Scheduled Removal	2	1.0	44	8.9
TOTALS	194	100.0%	493	100.0%

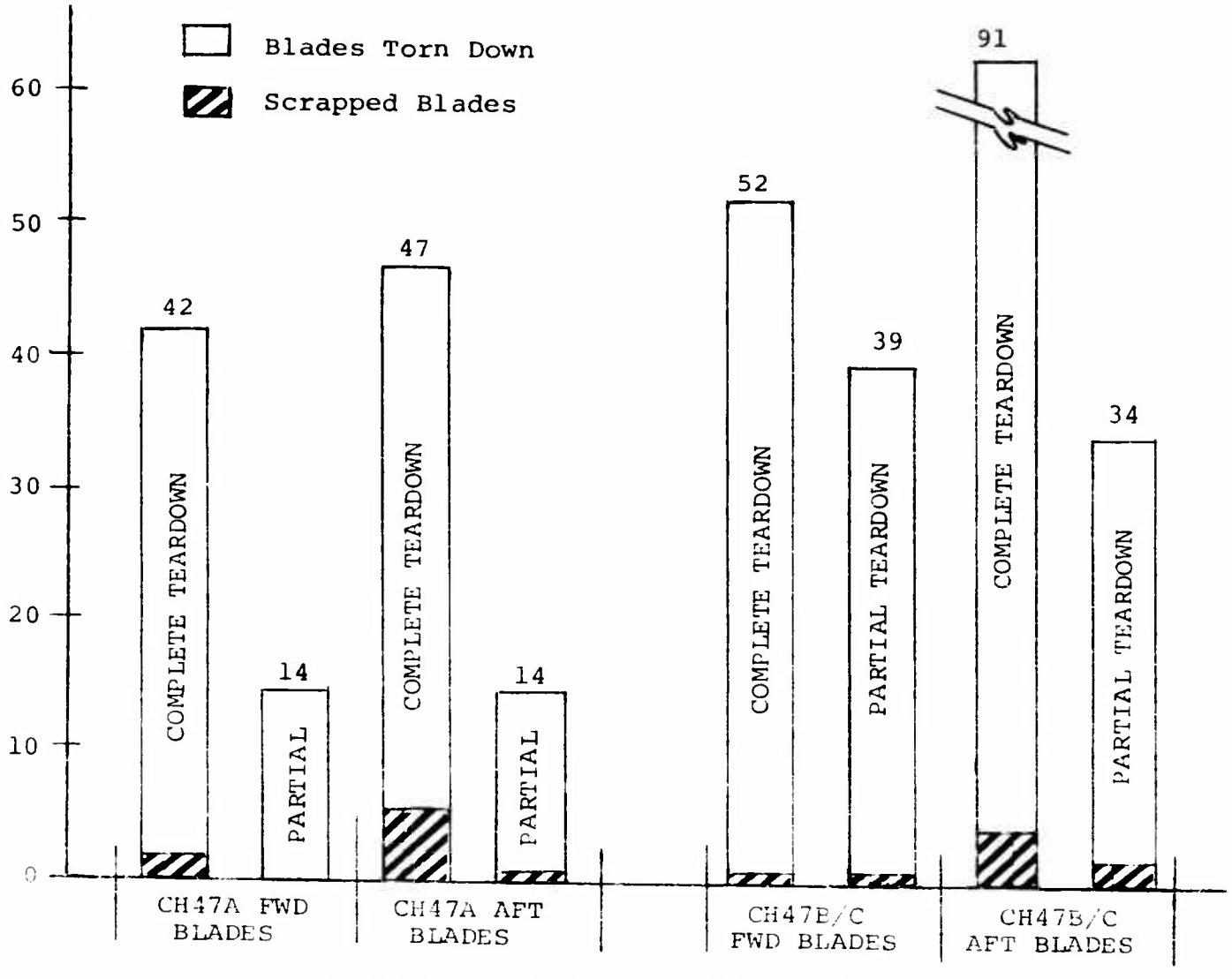


FIGURE 28. BLADE TEARDOWN EXPERIENCE.

TABLE XXXI. MEAN-TIME-BETWEEN-SCRAPPAGE - FORWARD AND AFT SCRAPPED BLADES - CH-47A

REASONS FOR SCRAP	FWD. SCRAPPED BLADES			AFT SCRAPPED BLADES		
	Qty. of Blades Scrapped	Fwd. Blade Flt. Hours	$MTBS_F$	Qty. of Blades Scrapped	Aft Blade Flt. Hours	$MTBS_F$
Foreign Object Damage	60		32,510	121		16,121
Dented	54		36,122	93		20,974
Broken				4		487,655
Torn		1,950,618		4	1,950,618	487,655
Punctured	4		487,655	15		130,041
Scored	2		975,309	2		975,309
Bent				3		650,206
Combat Damage	47		41,503	48		40,638
Broken				2		975,309
Scored						
Dented	20	1,950,618	97,531	15	1,950,618	130,041
Punctured	26		75,023	31		62,923
Torn						
Spar/Socket	1		1,950,618			
Crash/Strikes	20		97,531	12		162,552
Bent	1		1,950,618	1		1,950,618
Collapsed	8	1,950,618	243,828	1	1,950,618	1,950,618
Torn	1		1,950,618	6		325,103
Minor Damage	10		195,062	4		487,655
Error *	7		278,659	5		390,124
Mishandled	3	1,950,618	650,206	1	1,950,618	1,950,618
Shop Error	2		975,309	1		1,950,618
Arc Burn	2		975,309	3		650,206
Miscellaneous	60		32,510	307		6,354
Reached Life Limit	4		487,655	30		65,021
Deterioration		1,950,618			1,950,618	
Corroded	8		243,828	7		278,660
Cracked	1		1,950,618	3		650,206
Unbonded	1		1,950,618	6		325,103
Overstressed	44		44,332	317		8,989
Scheduled Removal	2		975,309	44		44,332
All Causes	194	1,950,618	10,055	493	1,950,618	3,957

* Error occurred During Manufacturing/Shipping/Maintenance or Field Repair

TABLE XXXII. MEAN-TIME-BETWEEN-SCRAPPAGE - FORWARD AND AFT SCRAPPED BLADES - CH-47B/C

REASONS FOR SCRAP	FWD. SCRAPPED BLADES			AFT SCRAPPED BLADES		
	Qty. of Blades Scrapped	Fwd. Blade Flt. Hours	$MTBS_F$	Qty. of Blades Scrapped	Aft Blade Flt. Hours	$MTBS_A$
Foreign Object Damage	20		44,716	29		30,476
Dented	15		59,623	23		38,427
Broken		894,339		1	883,824	883,824
Punctured	2		447,169	3		294,608
Scored	3		298,113	2		441,912
Combat Damage	25		35,774	19		46,517
Scored				1		883,824
Dented	14	894,339	63,881	9	883,824	98,203
Punctured	10		89,434	8		110,478
Torn	1		894,339	1		883,824
Crash/Strikes	4		223,585	14		63,130
Torn	1	894,339	894,339	1	883,824	883,824
Dented	3		298,113	13		67,986
Error *	2		447,169	2		441,912
Mishandled				2		441,912
Shop Error	1	894,339	894,339		883,824	
Arc Burn	1		894,339			
Miscellaneous	4		223,585	7		126,269
Corroded	1	894,339	894,339	3	883,824	294,608
Overstressed	3		298,113	4		220,956
All Causes	55	894,339	16,261	71	883,824	12,448

* Error Occurred During Manufacturing/Shipping/Maintenance Or Field Repair

TABLE XXXIII. SUMMARY OF CH-47A, B AND C SCRAPPED BLADE MEANS

BLADES		ALL CAUSES	FOREIGN OBJECT DAMAGE	COMBAT DAMAGE	CRASHES/ STRIKES	ERROR	MISC.
CH-47A	FORWARD	10,055	32,510	41,503	97,531	278,659	32,150
	AFT	3,957	16,121	40,638	162,552	390,124	6,354
CH-47B	FORWARD	16,261	44,716	35,774	223,585	447,169	223,585
	AFT	12,448	30,476	46,517	63,130	441,912	126,260

COST ANALYSIS

A comparison of the CH-47 rotor blade acquisition cost and the average cost of repaired/reworked rotor blades was made. Included in the total average cost of the repaired/reworked blades is a $40.00 transportation cost to and from New Cumberland Army Depot (NCAD).

Table XXXVI of Appendix I identifies the various CH-47A (114R1002) and CH-47B/C (114R1502) blades by part number and location. The table shows a selected quantity of blades, transportation costs to and from NCAD, the average repair/rework costs per blade, and the acquisition costs per blade.

The cost comparison of the repair/rework average costs per blade versus the acquisition cost of a new blade is given by this table in percentages.

TABLE XXXIII. SUMMARY OF CH-47A, B AND C SCRAPPED BLADE MEANS

BLADES		ALL CAUSES	FOREIGN OBJECT DAMAGE	COMBAT DAMAGE	CRASHES/ STRIKES	ERROR	MISC.
CH-47A	FORWARD	10,055	32,510	41,503	97,531	278,659	32,150
	AFT	3,957	16,121	40,638	162,552	390,124	6,354
CH-47B	FORWARD	16,261	44,716	35,774	223,585	447,169	223,585
	AFT	12,448	30,476	46,517	63,130	441,912	126,260

CONCLUSIONS AND RECOMMENDATIONS

Removal summaries for all CH-47A blades are given by Table XXXIV and for all CH-47 B/C blades by Table XXXV. As a result of review of these tables and the entire study, the following conclusions and recommendations are made:

1. Existing field repair techniques, criteria and/or practices for bonded rotor blades may be inadequate. The detailed data used for this study can be utilized to determine where the inadequacies occur. Recommendations for cost-effective improvements to repair techniques, equipment, procedures and personnel training can be made on the basis of these determinations.

2. Trend curves showing the rate of improvement of mean-time parameters for early CH-47A blades through the latest CH-47B/C blades can be derived from the data bank used for this study. Design recommendations based on information extracted and analyzed from the present data bank could lead to improved blade configurations.

3. This analysis indicates that returned blades intended for repair/overhaul are being retired or scrapped at periods somewhat less than published life limits. This requires a consideration of acquisition costs in comparison to repair costs and the life remaining in the blade. However, at present, a definitive cost/break-even scale is not available to guide this early retirement practice. Data extracted for this study can be utilized to develop an optimum life limit/repair costs scale for aiding the decision to retire late-life blades.

4. The quantity of blades needed to provide a representative sample for meaningful analyses is presently unknown. The CH-47A blade data should be analyzed in smaller groups by manufacturing date and compared to the total results to determine the number required for a representative sample. The CH-47B/C blade analysis should be continued until a representative sample is completed.

5. To provide a calendar year analysis of blade discrepancies, the present data should be related to blade manufacturing and repair dates and a yearly updating of the overhaul/repair data should be performed.

TABLE XXXIV. REMOVAL SUMMARY DISTRIBUTION - ALL DISCREPANCIES - CH-47A REPAIRED AND SCRAPPED BLADES

	REMOVAL	REASON	Fwd Rotor Blades Total Blades	Fwd Rotor Blades % of Total	Aft Rotor Blades Total Blades	Aft Rotor Blades % of Total	All Blades Total Blades	All Blades % of Total
INHERENT DISCREPANCIES	Deterior.	Loose/Missing	14	0.66	1	0.04	15	0.34
		Bare Steel	1	0.05	18	0.77	19	0.43
		Eroded	14	0.66	15	0.64	29	0.65
		Rippled	3	0.14	4	0.17	7	0.16
		Water Migrate	1	0.05			1	0.02
	Unbond	Bulged	6	0.28	2	0.09	8	0.18
		Blistered	1	0.05			1	0.02
		Bond Void	122	5.74	144	6.13	266	5.94
	Vibration	Beyond Tolerance	8	0.38	1	0.04	9	0.20
		Vibration	8	0.38	2	0.09	10	0.22
	Eroded	Worn	54	2.54	9	0.38	63	1.40
		Eroded	18	0.85	9	0.38	27	0.60
	Corrosion	Corroded	141	6.63	99	4.22	240	5.36
		Peeling						
		Chipped			10	0.42	10	0.22
		Stained						
		Seized	2	0.09	1	0.04	3	0.07
		Water Migrate						
		Pitted			1	0.04	1	0.02
	Delam.	Voided	40	1.88	11	0.47	51	1.14
		Crazed	2	0.09	1	0.04	3	0.07
		Cracked	5	0.24	23	0.98	25	0.63
		Split			19	0.81	19	0.43
	Cracked	Creased	1	0.05	14	0.60	15	0.34
		Crazed	2	0.09			2	0.04
		Cracked	195	9.17	338	14.39	533	11.91
		Split	2	0.09	10	0.42	12	0.27
	Fretted	Worn			1	0.04	1	0.02
		Fretted	1	0.05			1	0.02
	Balance	Tip Rod Loose	36	1.69	4	0.17	40	0.89
		Imbalance	15	0.70	4	0.17	19	0.43
	SUBTOTALS		692	32.55	741	31.54	1433	32.02
EXTERNAL DISCREPANCIES	F.O.D.	Dented	384	18.06	343	14.60	727	16.25
		Broken	14	0.66	25	1.06	39	0.87
		Torn	35	1.65	33	1.40	68	1.52
		Punctured	123	5.78	100	4.26	223	4.98
		Scored	54	2.54	48	2.04	102	2.28
		Bent	38	1.79	27	1.15	65	1.45
	Combat Damage	Broken	4	0.19	8	0.34	12	0.27
		Scored						
		Dented	34	1.60	34	1.45	68	1.52
		Punctured	106	4.98	98	4.30	204	4.56
		Torn						
		Spar/Socket	2	0.09			2	0.04
	Over-stress	Overstress	111	5.22	279	11.88	390	8.72
		Bent			1	0.04	1	0.02
		Collapsed						
		Fractured	1	0.05			2	0.04
		Dented	1	0.05	2	0.09	3	0.07
	Crashes/ Strikes	Bent	1	0.05	1	0.04	3	0.07
		Collapse	8	0.38	1	0.04	9	0.20
		Torn	1	0.05	11	0.47	12	0.27
		Minor Damage	25	1.17	8	0.34	33	0.74
	Manuf/Ship/Handling Error		33	1.55	11	0.47	45	1.00
	No Valid Removal		15	0.70	28	1.19	43	0.96
	Miscellaneous		1	0.05	3	0.13	4	0.09
	SUBTOTALS		991	46.61	1064	45.29	2055	45.92
SCHED. DISCR.	MWO Compliance		32	1.50	35	1.49	67	1.50
	No Defect (Sch. Maint.)		276	12.98	399	16.99	675	15.08
	Retired Blades		4	0.19	26	1.11	30	0.67
	EIR Engineering		2	0.09	2	.09	4	0.09
	No Defect (Fac. Maint.)		58	2.73	22	0.94	80	1.79
	Miscellaneous		71	3.34	60	2.55	131	2.93
	SUBTOTALS		443	20.83	544	23.17	987	22.06
	TOTALS		2126	100.00%	2349	100.00%	4475	100.00%

TABLE XXXV. REMOVAL SUMMARY DISTRIBUTION - ALL DISCREPANCIES - CH-47B/C REPAIRED AND SCRAPPED BLADES

	REMOVAL REASON		Forward Rotor Blades Total Blades	Forward Rotor Blades % of Total	Aft Rotor Blades Total Blades	Aft Rotor Blades % of Total	All Blades Total Blades	All Blades % of Total
Inherent Discrepancies	Deterior.	Loose/Missing Bare Steel Eroded Rippled Water Migr.	1	0.19	2	0.40	3	0.30
			1	0.19	2	0.40	3	0.30
	Unbonded	Bulged	30	5.86	26	5.19	56	5.53
		Blistered	16	3.13	39	7.78	55	5.43
		Bond Void	19	3.71	14	2.79	33	3.26
	Vibration	Beyond Tolerance			3	0.60	3	0.30
		Vibration	5	0.97	1	0.20	6	0.59
	Eroded	Worn	5	0.97			5	0.49
		Eroded	7	1.37	3	0.60	10	0.99
	Corrosion	Corroded Peeling Chipped Stained Seized Water Migr.	31 3	6.05 0.58	20 1	4.00 0.20	31 4	5.03 0.39
		Pitted	4	0.78	1	0.20	5	0.49
	Delam.	Voided	3	0.58	9	1.79	12	1.18
		Crazed	6	1.17			6	0.59
		Cracked	3	0.58	1	0.20	4	0.39
		Split	5	0.97			5	0.49
	Cracked	Creased Crazed Cracked Split	3 10	0.58 1.95	 5	 1.00	3 15	0.30 1.48
	Fretted	Worn						
		Fretted	1	0.19			1	0.10
	Imbalance	Tip Rod Loose			1	0.20	1	0.10
		Imbalance	3	0.58			3	0.30
	SUBTOTALS		156	30.40	128	25.55	284	28.04
External Discrepancies	F.O.D.	Dented	118	23.04	114	22.75	232	22.90
		Broken	1	0.19	1	0.20	2	0.20
		Torn	13	2.54	17	3.39	30	2.96
		Punctured	34	6.64	38	7.58	72	7.11
		Scored	4	0.78	9	1.79	13	1.28
		Bent	8	1.56	6	1.20	14	1.38
	Combat Damage	Broken	1	0.19			1	0.10
		Scored	3	0.58	1	0.20	4	0.39
		Dented	24	4.69	22	4.39	46	4.54
		Punctured	47	9.18	42	8.38	89	8.78
		Torn	2	0.39	4	0.80	6	0.59
		Spar/Socket	2	0.39			2	0.20
	Over-stress	Overstress	32	6.26	27	5.39	59	5.82
		Bent	1	0.19			1	0.10
		Collapsed						
		Fractured						
		Dented	3	0.58	5	1.00	8	0.79
	Crashes/ Strikes	Bent	1	0.19			1	0.10
		Collapse						
		Torn			3	0.60	3	0.30
		Minor Damage	1	0.19	13	2.59	14	1.38
	Manuf/Ship/Hand. Error		6	1.17	5	1.00	11	1.09
	No Valid Removal Reason		16	3.13	23	4.59	39	3.85
	Miscellaneous							--
	SUBTOTALS		317	61.86	330	65.87	647	63.86
Sch. Discr.	MWO Compliance		2	0.39	13	2.59	15	1.48
	No Defect (Sch.Maint.)		23	4.49	24	4.79	47	4.64
	Retired Blades							
	EIR Engineering		2	0.39			2	0.20
	No Defect (Comp. Rmvl)		10	1.95	6	1.20	16	1.58
	Miscellaneous		2	0.39			2	0.20
	SUBTOTALS		39	7.61	43	8.58	82	8.10
	TOTALS		512.	100.00%	501	100.00%	1013	100.00

LITERATURE CITED

(1) ARMY EQUIPMENT RECORD PROCEDURES, Department of The Army, Technical Manual 38-750; Headquarters, Department of The Army, May 1967; Appendix 1, Codes p. A1-1 through A1-8.

(2) ORGANIZATIONAL MAINTENANCE MANUAL, ARMY MODEL CH-47A HELICOPTER, Department of The Army Technical Manual-55-1520-209-20-1; Headquarters, Department of The Army, May 1968; Chapter 8, Section II, p. 8-3 through 8-12J.

(3) ORGANIZATIONAL MAINTENANCE MANUAL, ARMY MODEL CH-47B AND CH-47C HELICOPTER, Department of The Army Technical Manual-55-1520-227-20-1; Headquarters, Department of The Army, August 6, 1970; Chapter 8, Section II, p. 8-3 through 8-11.

(4) DS, GS AND DEPOT MAINTENANCE MANUAL, ARMY MODEL CH-47A HELICOPTER, Department of The Army, Technical Manual 55-1520-209-35-2; Headquarters, Department of The Army, May 1968, Chapter 18, Section II, p. 18-49 through 18-96C.

(5) DS, GS, AND DEPOT MAINTENANCE MANUAL, ARMY MODEL CH-47B AND CH-47C HELICOPTER, Department of The Army, Technical Manual 55-1520-227-35-3; Headquarters, Department of The Army, August 6, 1970; Chapter 18, Section II, p. 18-41 through 18-72.

(6) ORGANIZATIONAL MAINTENANCE MANUAL, ARMY MODEL CH-47A HELICOPTER, Department of The Army Technical Manual 55-1520-209-20-1; Headquarters, Department of The Army, May 1968; Chapter 3, Section IV, p. 3-65 through 3-66.

(7) ORGANIZATIONAL MAINTENANCE MANUAL, ARMY MODEL CH-47B AND CH-47C HELICOPTER, Department of The Army Technical Manual 55-1520-227-20-1; Headquarters, Department of The Army, August 6, 1970; Chapter 3, Section V, p. 3-82.

(8) ARMY EQUIPMENT RECORD PROCEDURES, Department of The Army Technical Manual 38-750; Headquarters, Department of The Army, May 1967; Chapter 3, Paragraph 3-8, p. 3-73 through 3-100.

APPENDIX I
COST ANALYSIS

The objective of this cost analysis was to analyze the aircraft support costs for rotor blades to determine the average comparative costs of new versus repair/rework blades.

Table XXXVI is provided to indicate results of this analysis.

TABLE XXXVI. COST COMPARISON - CH-47 NEW VS. REPAIR/REWORK BLADES

Component	Qty. Sample Blades	Transportation To & From NCAD	Total Aver.Costs Per Blade	Acquisition Cost Per Blade	Repair/Rework vs. New
Fwd. Rotor Blade (114R1002)	939	$40.00/Blade	$2,808	$13,200	21.3%
Aft Rotor Blade (114R1002)	919	$40.00/Blade	$2,416	$13,200	18.3%
Fwd. and Aft Blade Avg. (114R1002)	1,858	$40.00/Blade	$2,614	$13,200	19.8%
Fwd. Rotor Blade (114R1502)	106	$40.00/Blade	$2,175	$13,800	15.8%
Aft Rotor Blade (114R1502)	60	$40.00/Blade	$2,413	$13,800	17.5%
Fwd. and Aft Blade Avg. (114R1502)	166	$40.00/Blade	$2,261	$13,800	16.4%

These costs do not include replacement parts which are GFE. Costs were derived from completed government delivery orders from July 1967 through March 1971.

APPENDIX II
DATA EXTRACTION PROCESS

A data extraction procedure was developed and applied to locate, extract and describe CH-47 rotor blade discrepancies investigated for the purposes of this report. This was done by using an alphanumeric coding system, expanded to accommodate identification of discrepancies within the entire structure of the CH-47 rotor blade. This alphanumeric system provides different codings for the CH-47A and CH-47B/C blades.

Each rotor blade returned to Vertol for repair is treated as if it were appearing in the overhaul system for the first time. A thorough inspection of the blade is made by the Quality Assurance Department. The results of this inspection, including follow-up inspection, are recorded on a Boeing-Vertol Inspection Report throughout the repair/overhaul process. Each rotor blade assembly upon receipt at Boeing-Vertol is usually accompanied by a Form DA-2410 originated and completed per Army Equipment Record Procedures, TM 38-750, Reference (8), by the using activity. This form will contain blade historical data. An internally originated SAV-HQ Form 391 (Component Disassembly Evaluation Summary) is also completed for contract purposes. Accuracy of subsequent data analysis is dependent upon the accuracy of these documents, as well as the experience of the reviewer of these forms.

The data extraction record devised for this study is comprised of three sheets containing historical data and primary and secondary discrepancy areas of interest under investigation. The sample forms shown are typical of analysis of CH-47A blades. Figure 29 contains historical and chronological data obtained and/or derived from SAV-HQ Form 391 and Form DA-2410. Figures 30 and 31 identify major and minor discrepancy areas in respect to the blade structure. Boeing-Vertol part numbers are included for identification purposes. Thus, a considerable amount of practical information concerning the effect of design, manufacture and operational experience of each rotor blade in the field is extracted in a readily available form. Figures 33 through 40 demonstrate the alphanumeric coding system for the CH-47A blades. A similar system was developed and employed for the CH-47B/C blades.

A concise description of the construction of the data recording sheets, Figures 29, 30 and 31, is given below to illustrate the depth of the data extraction process. Starting with Sheet 1 of the 3-sheet Data Extraction Record (Figure 29), the headings are largely self-explanatory, but the following is provided to indicate consistency of data interpretation:

1. Item No. - Necessary only for arithmetical continuity and identification of the blade being analyzed.

2. Serial No. - Serial number of blade being analyzed. A-1 indicates blades located on forward rotor head. A-2 indicates blades located on aft rotor head.

3. Dash No. - Indicates changes to basic configuration of blade at arrival (I) and when shipped out of Boeing-Vertol repair/overhaul activity (0).

4. TT - Total flight time on blade upon arrival at Boeing-Vertol. Time is obtained from DA-2410 and/or SAV-HQ Form 391 or Boeing Inspection Report. The DA-2410 form from the User Activity is the primary source of this information.

5. TSLR - Time since last repair which is determined from blade historical records and/or noted on DA-2410. Since each blade is considered new when shipped to Customer after repair/overhaul, this can be considered flight time since last repair.

6. Previous Repairs - Number of times blade has been repaired/overhauled at Boeing-Vertol before.

7. Life Limit - Total number of hours blade may be used under normal operating conditions without spar overstress condition. Appears in overhaul and retirement schedule of TM 55-1520-227-20-1 (Reference 6) for CH-47B/C blades. The life limit is fixed at 2400 for the aft CH-47A blades and 3600 for the forward CH-47A blades.

8. Date Received - Julian date blade is received at repair/overhaul facility.

9. Failure Code - Major discrepancy noted on DA-2410. Should the failure cause noted on DA-2410 be inconsistent with results of inspection as noted in Inspection Report, the obvious cause of failure should be noted under remarks.

Sheet 49 of 122

PART NUMBER: 114R1602 NOMENCLATURE: FWD [redacted] ROTOR BLADES Month Feb. Year 1971

ITEM	SER. NO. AI	DASH NO. I	DASH NO. C	TT	TSLR	PREVIOUS REMAIN LIFE	LIFE LIMIT	DATE RECEIVED	DATE REMOVED	FAILURE CODE	MODEL A/C	REMARKS
279	-208	19	33	210	—	0	3600	5112	5033	Unk	A	Blade delivered less socket
												DA #2410 incomplete
280	-208	33	57	1126	916	1	3600	0287	Unk	Unk	A	Complete Teardown - T/E damage
												* B/S intermittent skin to rib voids
												Box #2, #3, #4, #5, #7, #8, #9
281	-209	33	-	368	—	0	NA	NA	6133	540	A	Scrap - Scrapped in field
282	-210	33	33	316	—	0	3600	6252	6198	200	A	Insp. did not reveal reason for removal.
283	-210	33	61	724	408	1	3600	9139	—	804	A	Complete teardown for spar insp.
												Dented nosecap obvious reason for removal.

FIGURE 29. DATA EXTRACTION RECORD - SHT. 1 - CH-47A.

Sheet 49B of 122B

Part Number: 114R1002 Nomenclature: FWD [redacted] ROTOR BLADE Month Feb. Year 1971

Item	Serial No. A	114R1210 Nose Cap	114R1077 Trans. Cap	114R1372 Tip Cover	114R1042 Spar	114R1043 Socket	NAS464P8L97 Incidence Bolt	114R1450 (2) Incidence Plugs	AN180-40 Clamp Land Bolt	114R1065 Fwd. Tip Wt.	114R1066 Aft Tip Wt.	114R1087 (4) Tracking Wt. Studs	114R1374 Channel	22R1102 Bal. Wt. Plug	114R1214 (4) Root Box Doublers	114R1215(46) D. C. Doublers	AB-4307 Hysol Sealer	EC2216 Sealer	EC1675 Sealer	[illegible]
279	-208			1 K Z	2 B2007 -2008 1802 B1974 -1975 1926 1879 1826					2 H						2 B2392 -2398 B2412 -2418				
280	-208	1 2212 L1472 +1470 L1418 -1420	1 B1 2283	1 K M B1	2 B200[illegible] -2008 B1969 -1975 1879 1823 1877	2 Z 2105 2092 2090 2165 2164			2 H	1 B1	1 B1	2 (4) H		2 L	1 B1759 -1768	1 B2392 -2398 B2412 -2418 B2319 -2398				
281	-209	1 B1507			1 B2056															
282	-210			1 H K	B1975 1879 2171 2086							2 (4) H				2 B2398				
283	-210	1 L1458 L1445 2200	1 W	1 P W	2 B1975					1 W	1 W									1 W

FIGURE 30. DATA EXTRACTION RECORD - SHT. 2 - CH-47A.

Part Number: 114R1002 Nomenclature: FWD [redacted] ROTOR BLADE

Sheet 49A of 122A

Month Feb. Year 1971

Item	Serial No. A	114R1004 #1 Root Box	114R1005 #2 Basic Box	114R1005 #3 Basic Box	114R1005 #4 Basic Box	114R1005 #5 Basic Box	114R1005 #6 Basic Box	114R1005 #7 Basic Box	114R1005 #8 Basic Box	114R1005 #9 Basic Box	114R1005 #10 Basic Box	114R1005 #11 Basic Box	114R1006 #12 Tip Box	114R1059 (2) End Ribs Root Box	114R1051 (20) End Ribs Basic Boxes	114R1063 (2) End Ribs Tip Box	114R1052 (82) Basic Ribs - All Boxes	114R1056 Tie Down Bracket	114F1012 Trailing Edge	114F1363 Trim Tab
279	-208			2 T356	2 T354 -355	1 2226					2 B355 T356			1 T803						
280	-208	1 2213 2226	1 2214 2226	1 2214 2226	1 2214 2226	1 2214 2226	1 2214	1 2214 2226	1 2214 2226	1 2214	1 2214	1 2215 B546 H356 -562 B567 -568 B551 -552		1 *	1 T1108 B1108	1 *	1 K	1 742 1060 964 1096	1 2217 856	
281	-209																			
282	-210	1 2219															2 K			
283	-210	1 2201	1 2202	1 2202	1 2202	1 2202	1 2202	1 2202	1 2202	1 T410 B410 T334 -336 B334 -336	1 T341 1346 B341 1346	1 2202	1 2203	1 785 -791	1 789 -1106	1 1107 1108	1 T1005 B1005 785 -1108		1 2204 1012 1096	1 2205

FIGURE 31. DATA EXTRACTION RECORD - SHT. 3 - CH-47A.

10. Model A/C - A, B or C aircraft, as applicable.

11. Remarks - Major discrepancies, dispositions, or actions taken during repair or overhaul should be noted. Notations such as scrap, complete teardown, partial teardown, TBO Sample, EIR Sample including number, are included. If the blade has been shipped to the Customer, an 'Ⓢ' is placed in the remarks column. If a Boroscope inspection has been completed, a 'Ⓑ' is placed in the remarks column.

Sheet 2 of the Data Extraction Record (Figure 30) and Sheet 3 (Figure 31) provided column headings in terms of the various blade major assemblies and/or subassemblies. Physical and/or environmental damage to the blade surfaces and structure as described in the Inspection Report was analyzed in respect to the primary discrepancy which resulted in blade rework and/or scrappage. Codings which were used are described below:

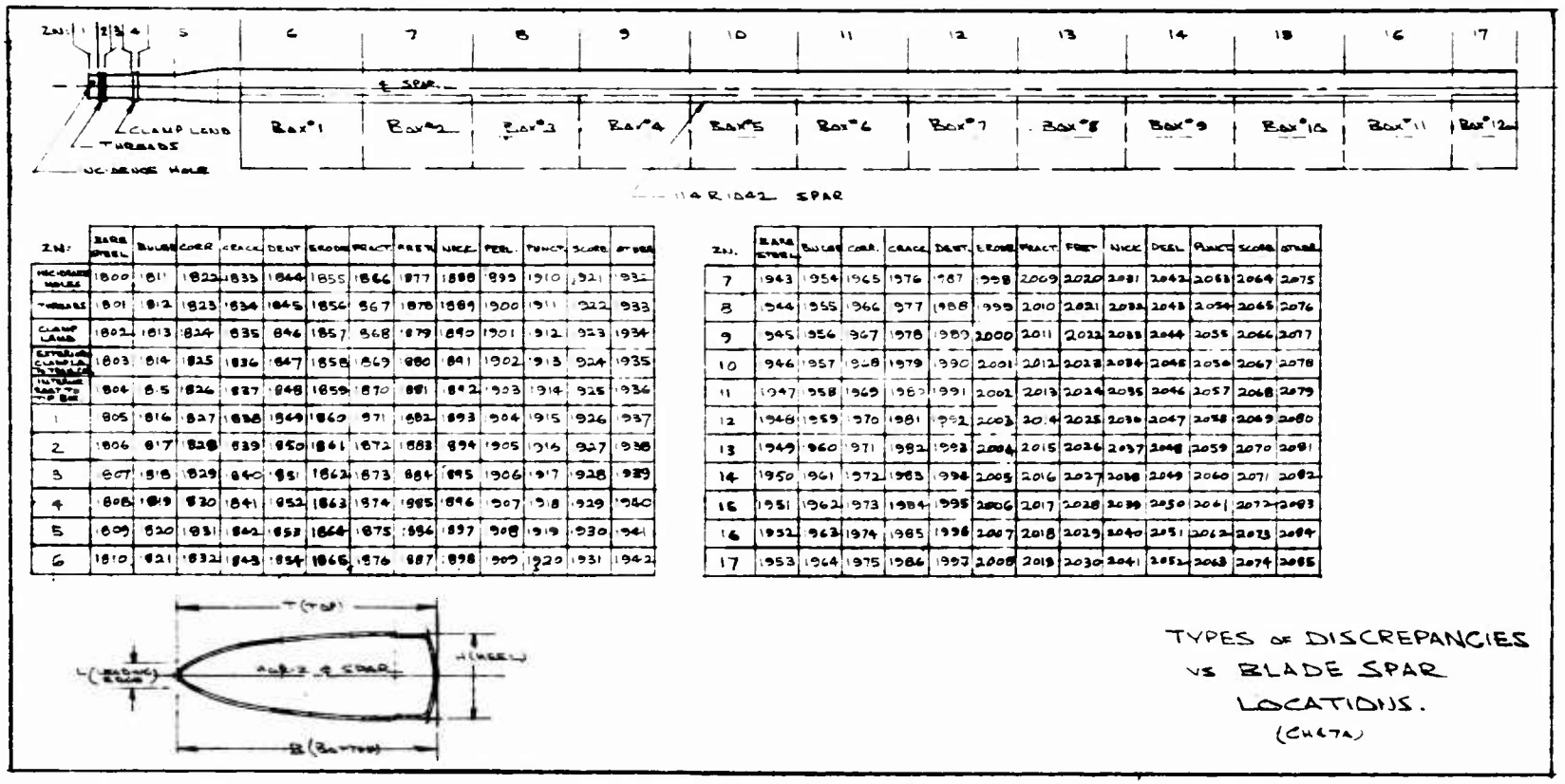
1. A major discrepancy which resulted in scrappage of a part or parts and which was also the cause of blade removal from the aircraft was denoted by placing a '①' in the upper left-hand corner of the appropriate line for that blade. Several examples are shown in Figure 30. Subsequent discrepancies also affecting that part are noted in the same column beneath the first entry.

2. A major discrepancy which was considered the primary reason for blade scrappage, but not the blade removal reason, was denoted by placing a '1' similar to point 1 above. Subsequent discrepancies are noted below this entry.

3. A major discrepancy which required rework or overhaul of a part or parts and which was determined as the blade removal cause was denoted by placing a '②' in the upper left-hand corner of the appropriate line for that blade. Subsequent discrepancies are noted below this entry.

4. Major blade discrepancies were plotted generally in grid form against blade locations as shown by Figures 32 through 40. Different numbers are employed for each different blade location and particular discrepancy. In those cases where the locating grid was inadequate to describe location, an alphabetical prefix was added to the location number. Alpha prefixes used were 'T' for top of blade, 'B' for bottom of blade, 'L' for leading edge, 'I' for spar interior, etc.

5. Discrepancies of secondary importance were described by use of a simple alphanumeric code which is part of the Boeing/Vertol CH-47 Overhaul Data Fact Sheet.

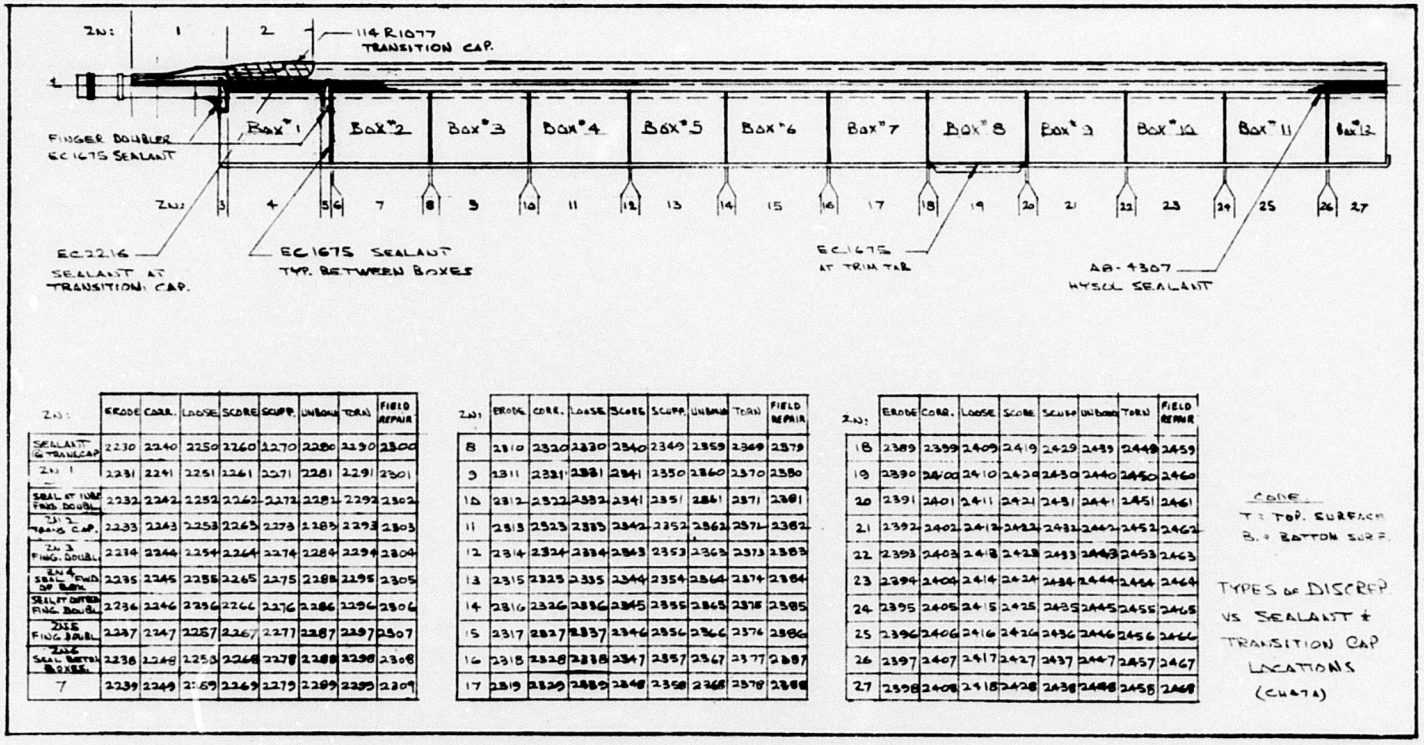


ZN:	BARE STEEL	BULGE	CORR.	CRACK	DENT	EROSION	FRACT.	FRET.	NICK	PEEL	PUNCT.	SCORE	OTHER
HOLES	1800	811	1822	1833	1844	1855	1866	1877	1888	1899	1910	1921	1932
THREADS	1801	1812	1823	1834	1845	1856	1867	1878	1889	1900	1911	1922	1933
CLAMP LAND	1802	1813	1824	1835	1846	1857	1868	1879	1890	1901	1912	1923	1934
OUTBOARD	1803	1814	1825	1836	1847	1858	1869	1880	1891	1902	1913	1924	1935
INBOARD	1804	1815	1826	1837	1848	1859	1870	1881	1892	1903	1914	1925	1936
1	1805	1816	1827	1838	1849	1860	1871	1882	1893	1904	1915	1926	1937
2	1806	1817	1828	1839	1850	1861	1872	1883	1894	1905	1916	1927	1938
3	1807	1818	1829	1840	1851	1862	1873	1884	1895	1906	1917	1928	1939
4	1808	1819	1830	1841	1852	1863	1874	1885	1896	1907	1918	1929	1940
5	1809	1820	1831	1842	1853	1864	1875	1886	1897	1908	1919	1930	1941
6	1810	1821	1832	1843	1854	1865	1876	1887	1898	1909	1920	1931	1942

ZN.	BARE STEEL	BULGE	CORR.	CRACK	DENT.	EROSION	FRACT.	FRET.	NICK	PEEL	PUNCT.	SCORE	OTHER
7	1943	1954	1965	1976	1987	1998	2009	2020	2031	2042	2053	2064	2075
8	1944	1955	1966	1977	1988	1999	2010	2021	2032	2043	2054	2065	2076
9	1945	1956	1967	1978	1989	2000	2011	2022	2033	2044	2055	2066	2077
10	1946	1957	1968	1979	1990	2001	2012	2023	2034	2045	2056	2067	2078
11	1947	1958	1969	1980	1991	2002	2013	2024	2035	2046	2057	2068	2079
12	1948	1959	1970	1981	1992	2003	2014	2025	2036	2047	2058	2069	2080
13	1949	1960	1971	1982	1993	2004	2015	2026	2037	2048	2059	2070	2081
14	1950	1961	1972	1983	1994	2005	2016	2027	2038	2049	2060	2071	2082
15	1951	1962	1973	1984	1995	2006	2017	2028	2039	2050	2061	2072	2083
16	1952	1963	1974	1985	1996	2007	2018	2029	2040	2051	2062	2073	2084
17	1953	1964	1975	1986	1997	2008	2019	2030	2041	2052	2063	2074	2085

TYPES OF DISCREPANCIES VS BLADE SPAR LOCATIONS. (CH47A)

FIGURE 32. ALPHANUMERIC CODE - SHT. 1 - CH-47A.



ZN:	ERODE	CORR.	LOOSE	SCORE	SCUFF	UNBOND	TORN	FIELD REPAIR
SEALANT @ TRANSCAP	2230	2240	2250	2260	2270	2280	2290	2300
ZN 1	2231	2241	2251	2261	2271	2281	2291	2301
SEAL AT TUBE FING DOUBL	2232	2242	2252	2262	2272	2282	2292	2302
ZN 2 BOX 1 CAP	2233	2243	2253	2263	2273	2283	2293	2303
ZN 3 FING DOUBL	2234	2244	2254	2264	2274	2284	2294	2304
ZN 4 SEAL FING OF BOX	2235	2245	2255	2265	2275	2285	2295	2305
SEALANT BETWEEN FING DOUBL	2236	2246	2256	2266	2276	2286	2296	2306
ZN 5 FING DOUBL	2237	2247	2257	2267	2277	2287	2297	2307
ZN 6 SEAL BETWN BOXES	2238	2248	2258	2268	2278	2288	2298	2308
7	2239	2249	2259	2269	2279	2289	2299	2309

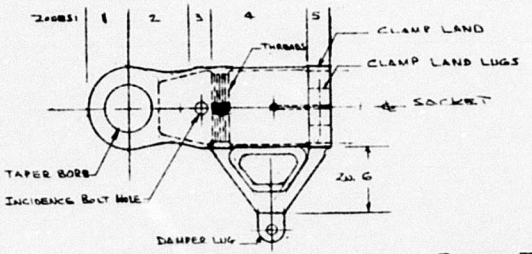
ZN:	ERODE	CORR.	LOOSE	SCORE	SCUFF	UNBOND	TORN	FIELD REPAIR
8	2310	2320	2330	2340	2349	2359	2369	2379
9	2311	2321	2331	2341	2350	2360	2370	2380
10	2312	2322	2332	2341	2351	2361	2371	2381
11	2313	2323	2333	2342	2352	2362	2371	2382
12	2314	2324	2334	2343	2353	2363	2373	2383
13	2315	2325	2335	2344	2354	2364	2374	2384
14	2316	2326	2336	2345	2355	2365	2375	2385
15	2317	2327	2337	2346	2356	2366	2376	2386
16	2318	2328	2338	2347	2357	2367	2377	2387
17	2319	2329	2339	2348	2358	2368	2378	2388

ZN:	ERODE	CORR.	LOOSE	SCORE	SCUFF	UNBOND	TORN	FIELD REPAIR
18	2389	2399	2409	2419	2429	2439	2449	2459
19	2390	2400	2410	2420	2430	2440	2450	2460
20	2391	2401	2411	2421	2431	2441	2451	2461
21	2392	2402	2412	2422	2432	2442	2452	2462
22	2393	2403	2413	2423	2433	2443	2453	2463
23	2394	2404	2414	2424	2434	2444	2454	2464
24	2395	2405	2415	2425	2435	2445	2455	2465
25	2396	2406	2416	2426	2436	2446	2456	2466
26	2397	2407	2417	2427	2437	2447	2457	2467
27	2398	2408	2418	2428	2438	2448	2458	2468

CODE
T = TOP SURFACE
B = BOTTOM SURF.

TYPES OF DISCREP VS SEALANT & TRANSITION CAP LOCATIONS (CH47A)

FIGURE 33. ALPHANUMERIC CODE - SHT. 2 - CH-47A.



SOCKET EXTERIOR

	CORR.	FRET	NICK	SCORE	BARE STEEL	BENT
TAPER BORE	2086	2099	2112	2126	2138	2151
INCIDENCE BOLT HOLE	2087	2100	2113	2126	2139	2152
AREA OF INCIDENCE BOLT HOLE	2088	2101	2114	2127	2140	2153
CLAMP LAND LUGS	2089	2102	2115	2128	2141	2154
CLAMP LAND HOLES	2090	2103	2116	2129	2142	2155
DAMPER LUG	2091	2104	2117	2130	2143	2156
DAMPER LUG HOLE	2092	2105	2118	2131	2144	2157
ZN 1	2093	2106	2119	2132	2145	2158
2	2094	2107	2120	2133	2146	2159
3	2095	2108	2121	2134	2147	2160
4	2096	2109	2122	2135	2148	2161
5	2097	2110	2123	2136	2149	2162
6	2098	2111	2124	2137	2150	2163

SOCKET INTERIOR

	CORR.	FRET	NICK	SCORE	BARE STEEL	OTHER
THREADS	2164	2170	2176	2182	2188	2194
INTERIOR CLAMP LAND	2165	2171	2177	2183	2189	2195
ZN 2	2166	2172	2178	2184	2190	2196
3	2167	2173	2179	2185	2191	2197
4	2168	2174	2180	2186	2192	2198
5	2169	2175	2181	2187	2193	2199

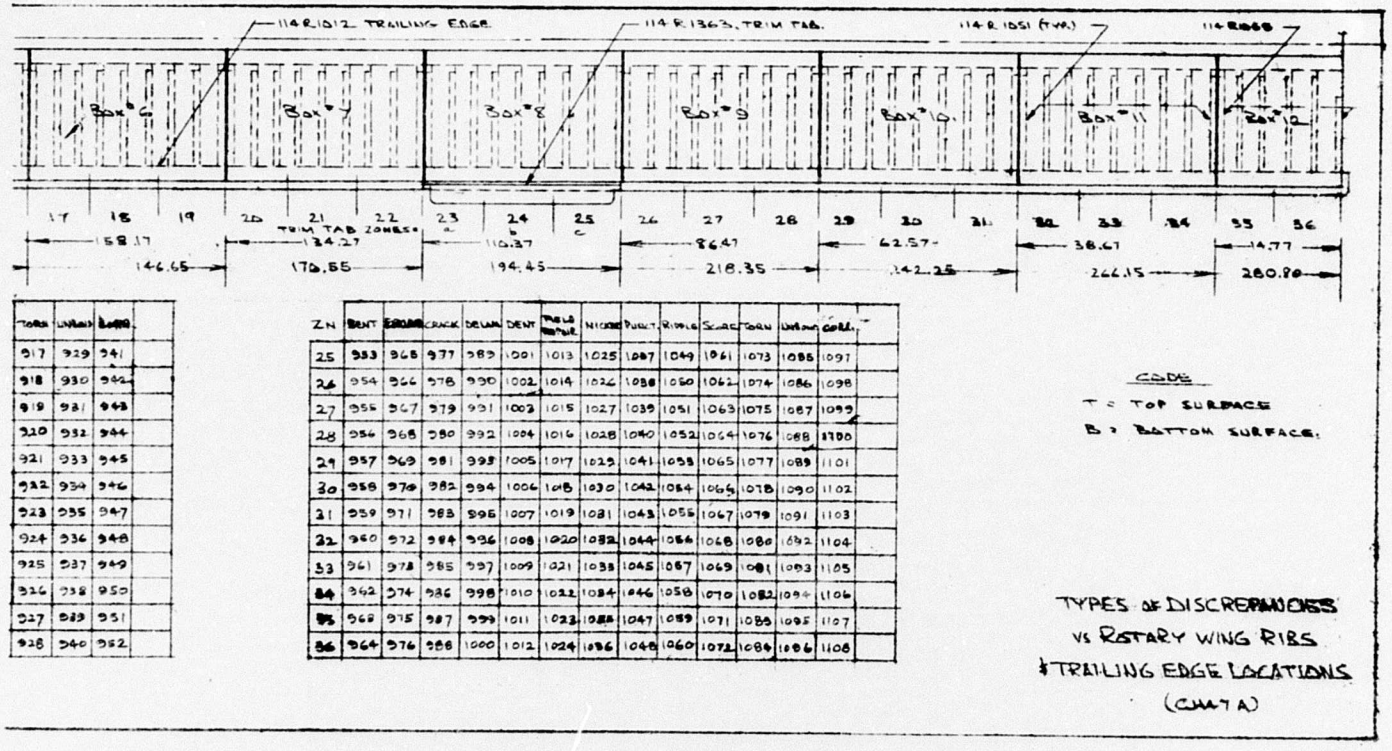
SOCKET 114R1043

REMOVALS FOR REWORK/INSPECTION.

	REMOVE TO FACILITATE REWORK & INSPECTION OF SPAR	REMOVE TO FACILITATE BOX REWORK	REMOVE TO FACILITATE REWORK AT TRAILEDGE	MWS	RIP DESCREP
L.E. NOSE CAP	2200	2206	2212	2218	2224
ROOT BOX	2201	2207	2213	2219	2225
BASIC BOX	2202	2208	2214	2220	2226
TIP BOX	2203	2209	2215	2221	2227
TRAIL. EDGE	2204	2210	2216	2222	2228
TRIM TAB	2205	2211	2217	2223	2229

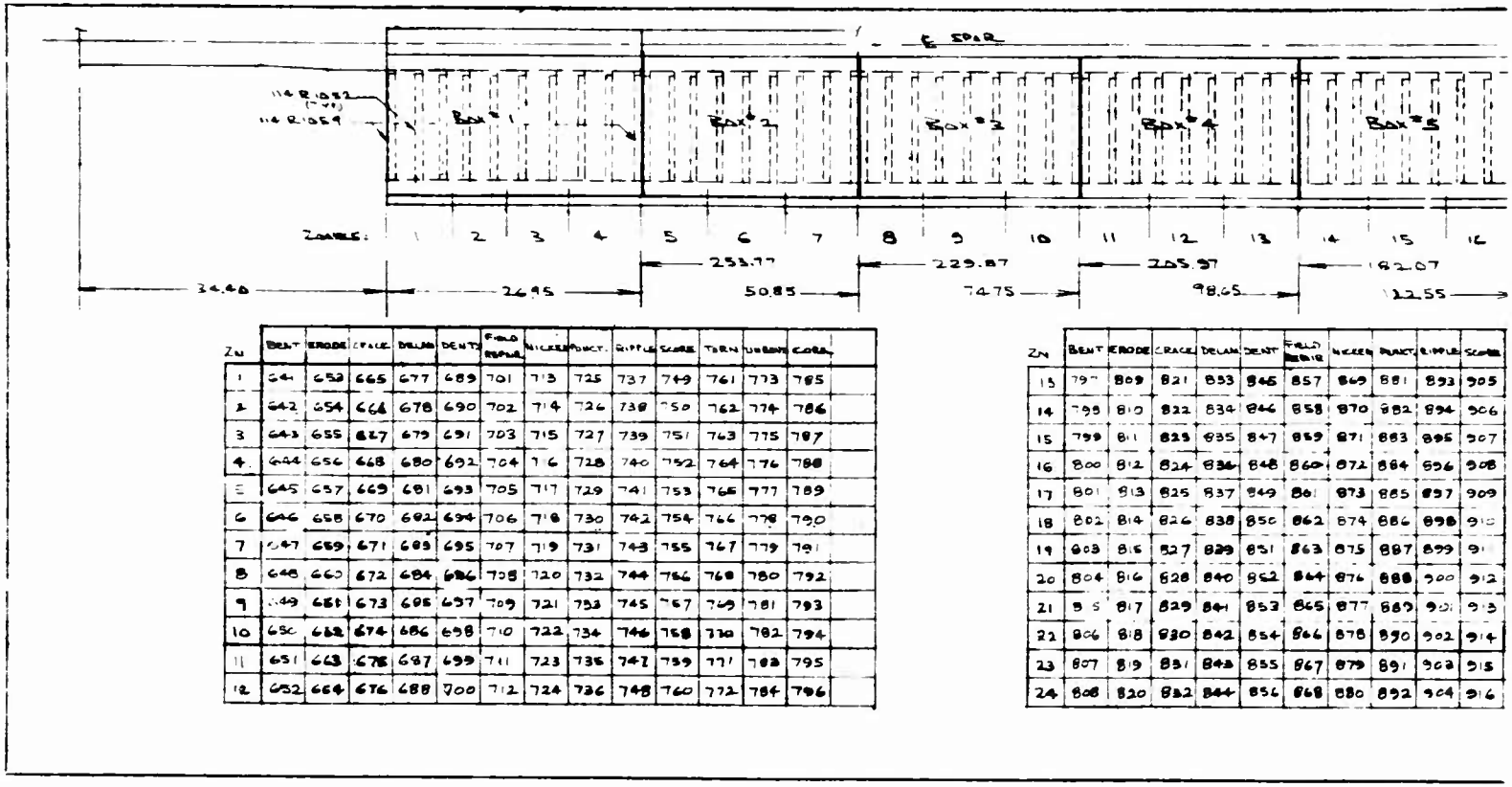
TYPES OF DISCREPANCIES VS SOCKET & REMOVALS FOR REWORK/INSPECT. (CH47A)

FIGURE 34. ALPHANUMERIC CODE - SHT. 3 - CH-47A.



ZN	DENT	EROSION	CRACK	DELAM	DENT	FIELD REPAIR	NICKS	PUNCT	RIVET	SCRATCH	TORN	UNKNOWN	CORR.
25	953	965	977	989	1001	1013	1025	1037	1049	1061	1073	1085	1097
26	954	966	978	990	1002	1014	1026	1038	1050	1062	1074	1086	1098
27	955	967	979	991	1003	1015	1027	1039	1051	1063	1075	1087	1099
28	956	968	980	992	1004	1016	1028	1040	1052	1064	1076	1088	1100
29	957	969	981	993	1005	1017	1029	1041	1053	1065	1077	1089	1101
30	958	970	982	994	1006	1018	1030	1042	1054	1066	1078	1090	1102
31	959	971	983	995	1007	1019	1031	1043	1055	1067	1079	1091	1103
32	960	972	984	996	1008	1020	1032	1044	1056	1068	1080	1092	1104
33	961	973	985	997	1009	1021	1033	1045	1057	1069	1081	1093	1105
34	962	974	986	998	1010	1022	1034	1046	1058	1070	1082	1094	1106
35	963	975	987	999	1011	1023	1035	1047	1059	1071	1083	1095	1107
36	964	976	988	1000	1012	1024	1036	1048	1060	1072	1084	1096	1108

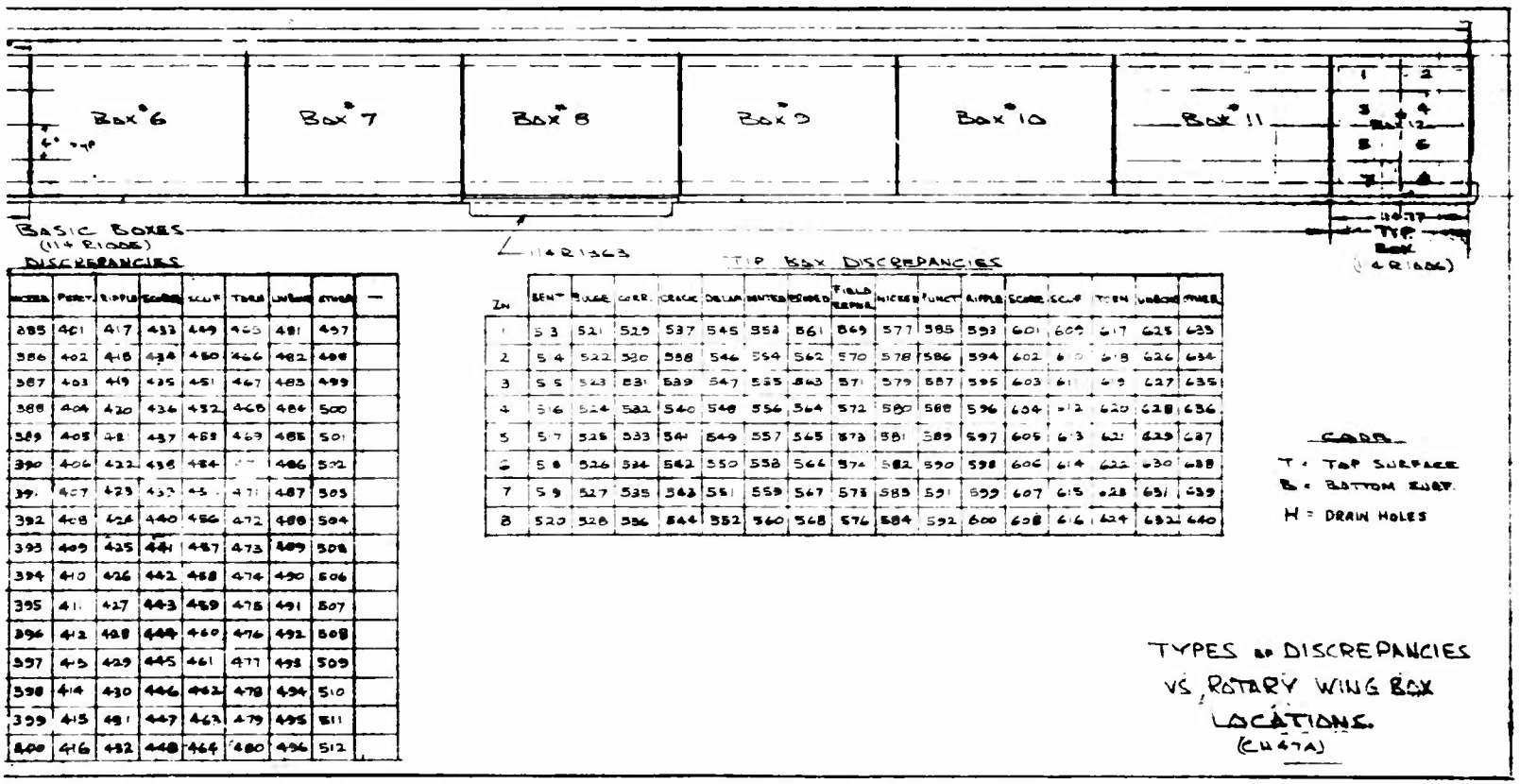
FIGURE 35. ALPHANUMERIC CODE - SHT. 4 - CH-47A.



ZN	BENT	ERODE	CRACK	DELAM	DENT	FIELD REPAIR	NICKEL	PUNCT.	RIPPLE	SCORE	TORN	UNBOND	GOUGE
1	641	653	665	677	689	701	713	725	737	749	761	773	785
2	642	654	666	678	690	702	714	726	738	750	762	774	786
3	643	655	667	679	691	703	715	727	739	751	763	775	787
4	644	656	668	680	692	704	716	728	740	752	764	776	788
5	645	657	669	681	693	705	717	729	741	753	765	777	789
6	646	658	670	682	694	706	718	730	742	754	766	778	790
7	647	659	671	683	695	707	719	731	743	755	767	779	791
8	648	660	672	684	696	708	720	732	744	756	768	780	792
9	649	661	673	685	697	709	721	733	745	757	769	781	793
10	650	662	674	686	698	710	722	734	746	758	770	782	794
11	651	663	675	687	699	711	723	735	747	759	771	783	795
12	652	664	676	688	700	712	724	736	748	760	772	784	796

ZN	BENT	ERODE	CRACK	DELAM	DENT	FIELD REPAIR	NICKEL	PUNCT.	RIPPLE	SCORE
13	797	809	821	833	845	857	869	881	893	905
14	798	810	822	834	846	858	870	882	894	906
15	799	811	823	835	847	859	871	883	895	907
16	800	812	824	836	848	860	872	884	896	908
17	801	813	825	837	849	861	873	885	897	909
18	802	814	826	838	850	862	874	886	898	910
19	803	815	827	839	851	863	875	887	899	911
20	804	816	828	840	852	864	876	888	900	912
21	805	817	829	841	853	865	877	889	901	913
22	806	818	830	842	854	866	878	890	902	914
23	807	819	831	843	855	867	879	891	903	915
24	808	820	832	844	856	868	880	892	904	916

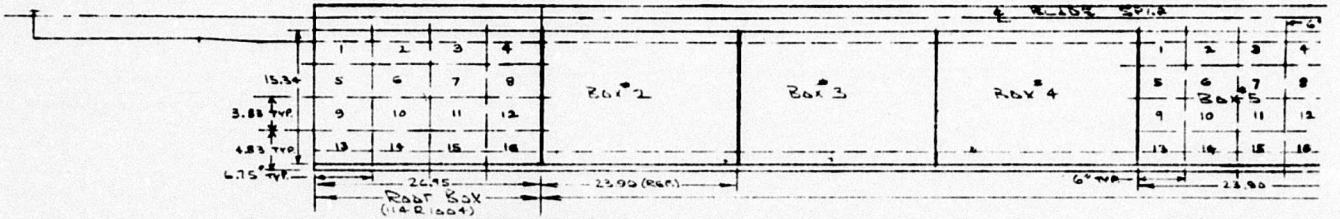
FIGURE 36. ALPHANUMERIC CODE - SHT. 5 - CH-47A.



385	401	417	433	449	465	481	497	
386	402	418	434	450	466	482	498	
387	403	419	435	451	467	483	499	
388	404	420	436	452	468	484	500	
389	405	421	437	453	469	485	501	
390	406	422	438	454	[illegible]	486	502	
391	407	423	439	455	471	487	503	
392	408	424	440	456	472	488	504	
393	409	425	441	457	473	489	505	
394	410	426	442	458	474	490	506	
395	411	427	443	459	475	491	507	
396	412	428	444	460	476	492	508	
397	413	429	445	461	477	493	509	
398	414	430	446	462	478	494	510	
399	415	431	447	463	479	495	511	
400	416	432	448	464	480	496	512	

IN																
1	53	521	529	537	545	553	561	569	577	585	593	601	609	617	625	633
2	54	522	530	538	546	554	562	570	578	586	594	602	610	618	626	634
3	55	523	531	539	547	555	563	571	579	587	595	603	611	619	627	635
4	56	524	532	540	548	556	564	572	580	588	596	604	612	620	628	636
5	57	525	533	541	549	557	565	573	581	589	597	605	613	621	629	637
6	58	526	534	542	550	558	566	574	582	590	598	606	614	622	630	638
7	59	527	535	543	551	559	567	575	583	591	599	607	615	623	631	639
8	520	528	536	544	552	560	568	576	584	592	600	608	616	624	632	640

FIGURE 37. **ALPHANUMERIC** CODE - SHT. 6 - CH-47A.



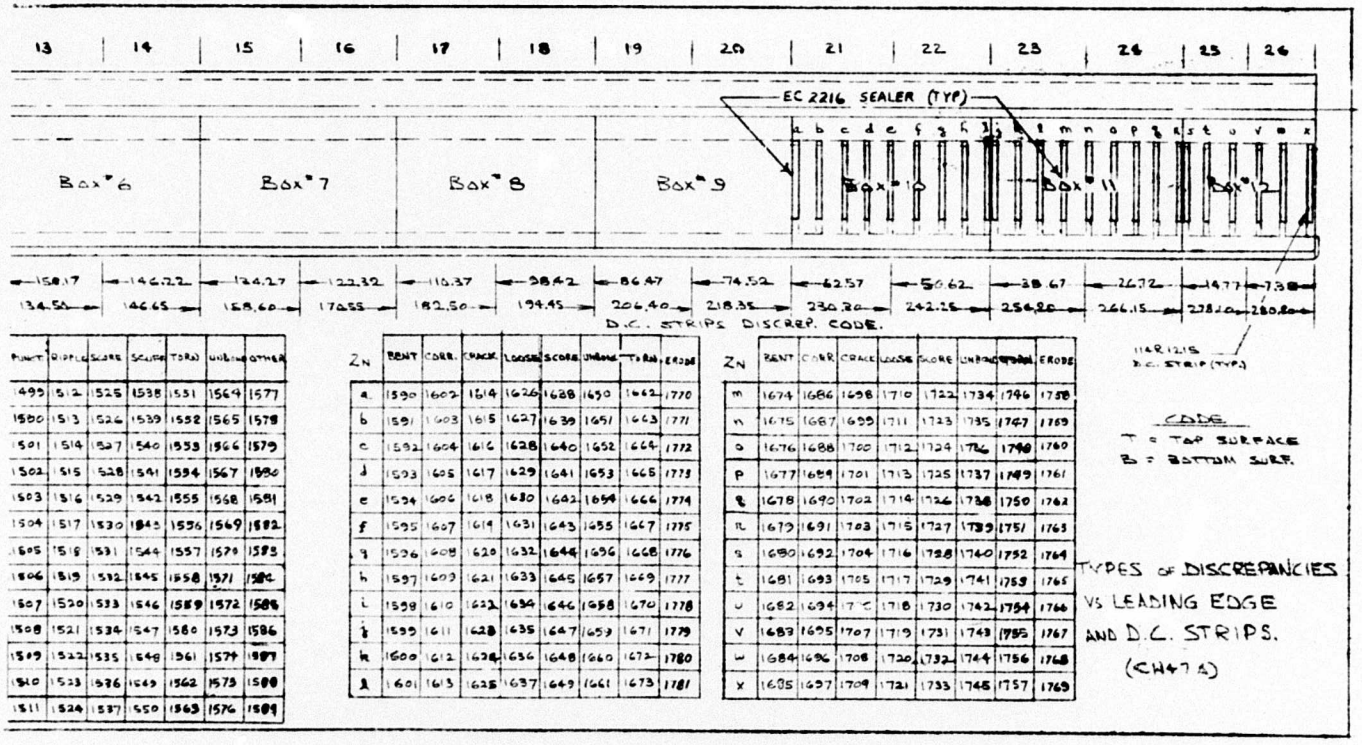
ROOT BOX DISCREPANCIES

ZN	DENT	BULGE	CORR.	CRACK	DELAM	DENTED	GROOVED	FIELD REPAIR	NICKED	PUNCT	RIPPLE	SCORE	SCUF	TORN	UNDERCUT	OTHER	—
1	1	17	33	49	65	81	97	113	129	145	161	177	193	209	225	241	
2	2	18	34	50	66	82	98	114	130	146	162	178	194	210	226	242	
3	3	19	35	51	67	83	99	115	131	147	163	179	195	211	227	243	
4	4	20	36	52	68	84	100	116	132	148	164	180	196	212	228	244	
5	5	21	37	53	69	85	101	117	133	149	165	181	197	213	229	245	
6	6	22	38	54	70	86	102	118	134	150	166	182	198	214	230	246	
7	7	23	39	55	71	87	103	119	135	151	167	183	199	215	231	247	
8	8	24	40	56	72	88	104	120	136	152	168	184	200	216	232	248	
9	9	25	41	57	73	89	105	121	137	153	169	185	201	217	233	249	
10	10	26	42	58	74	90	106	122	138	154	170	186	202	218	234	250	
11	11	27	43	59	75	91	107	123	139	155	171	187	203	219	235	251	
12	12	28	44	60	76	92	108	124	140	156	172	188	204	220	236	252	
13	13	29	45	61	77	93	109	125	141	157	173	189	205	221	237	253	
14	14	30	46	62	78	94	110	126	142	158	174	190	206	222	238	254	
15	15	31	47	63	79	95	111	127	143	159	175	191	207	223	239	255	
16	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240	256	

BASIC BOXES

ZN	DENT	BULGE	CORR.	CRACK	DELAM	DENTED	GROOVED	FIELD REPAIR
1	257	273	289	305	321	337	353	369
2	258	274	290	306	322	338	354	370
3	259	275	291	307	323	339	355	371
4	260	276	292	308	324	340	356	372
5	261	277	293	309	325	341	357	373
6	262	278	294	310	326	342	358	374
7	263	279	295	311	327	343	359	375
8	264	280	296	312	328	344	360	376
9	265	281	297	313	329	345	361	377
10	266	282	298	314	330	346	362	378
11	267	283	299	315	331	347	363	379
12	268	284	300	316	332	348	364	380
13	269	285	301	317	333	349	365	381
14	270	286	302	318	334	350	366	382
15	271	287	303	319	335	351	367	383
16	272	288	304	320	336	352	368	384

FIGURE 38. ALPHANUMERIC CODE - SHT. 7 - CH-47A.



PUNCT	RIPPLE	SCORE	SCUFF	TORN	UNBOND	OTHER
1499	512	1525	1538	1551	1564	1577
1500	513	1526	1539	1552	1565	1578
1501	1514	1527	1540	1553	1566	1579
1502	1515	1528	1541	1554	1567	1580
1503	1516	1529	1542	1555	1568	1581
1504	1517	1530	1543	1556	1569	1582
1505	1518	1531	1544	1557	1570	1583
1506	1519	1532	1545	1558	1571	1584
1507	1520	1533	1546	1559	1572	1585
1508	1521	1534	1547	1560	1573	1586
1509	1522	1535	1548	1561	1574	1587
1510	1523	1536	1549	1562	1575	1588
1511	1524	1537	1550	1563	1576	1589

ZN	DENT	CORR	CRACK	LOOSE	SCORE	UNBOND	TORN	ERODE
a	1590	1602	1614	1626	1638	1650	1662	1770
b	1591	1603	1615	1627	1639	1651	1663	1771
c	1592	1604	1616	1628	1640	1652	1664	1772
d	1593	1605	1617	1629	1641	1653	1665	1773
e	1594	1606	1618	1630	1642	1654	1666	1774
f	1595	1607	1619	1631	1643	1655	1667	1775
g	1596	1608	1620	1632	1644	1656	1668	1776
h	1597	1609	1621	1633	1645	1657	1669	1777
i	1598	1610	1622	1634	1646	1658	1670	1778
j	1599	1611	1623	1635	1647	1659	1671	1779
k	1600	1612	1624	1636	1648	1660	1672	1780
l	1601	1613	1625	1637	1649	1661	1673	1781

ZN	DENT	CORR	CRACK	LOOSE	SCORE	UNBOND	TORN	ERODE
m	1674	1686	1698	1710	1722	1734	1746	1758
n	1675	1687	1699	1711	1723	1735	1747	1759
o	1676	1688	1700	1712	1724	1736	1748	1760
p	1677	1689	1701	1713	1725	1737	1749	1761
q	1678	1690	1702	1714	1726	1738	1750	1762
r	1679	1691	1703	1715	1727	1739	1751	1763
s	1680	1692	1704	1716	1728	1740	1752	1764
t	1681	1693	1705	1717	1729	1741	1753	1765
u	1682	1694	1706	1718	1730	1742	1754	1766
v	1683	1695	1707	1719	1731	1743	1755	1767
w	1684	1696	1708	1720	1732	1744	1756	1768
x	1685	1697	1709	1721	1733	1745	1757	1769

FIGURE 39. ALPHANUMERIC CODE - SHT. 8 - CH-47A.

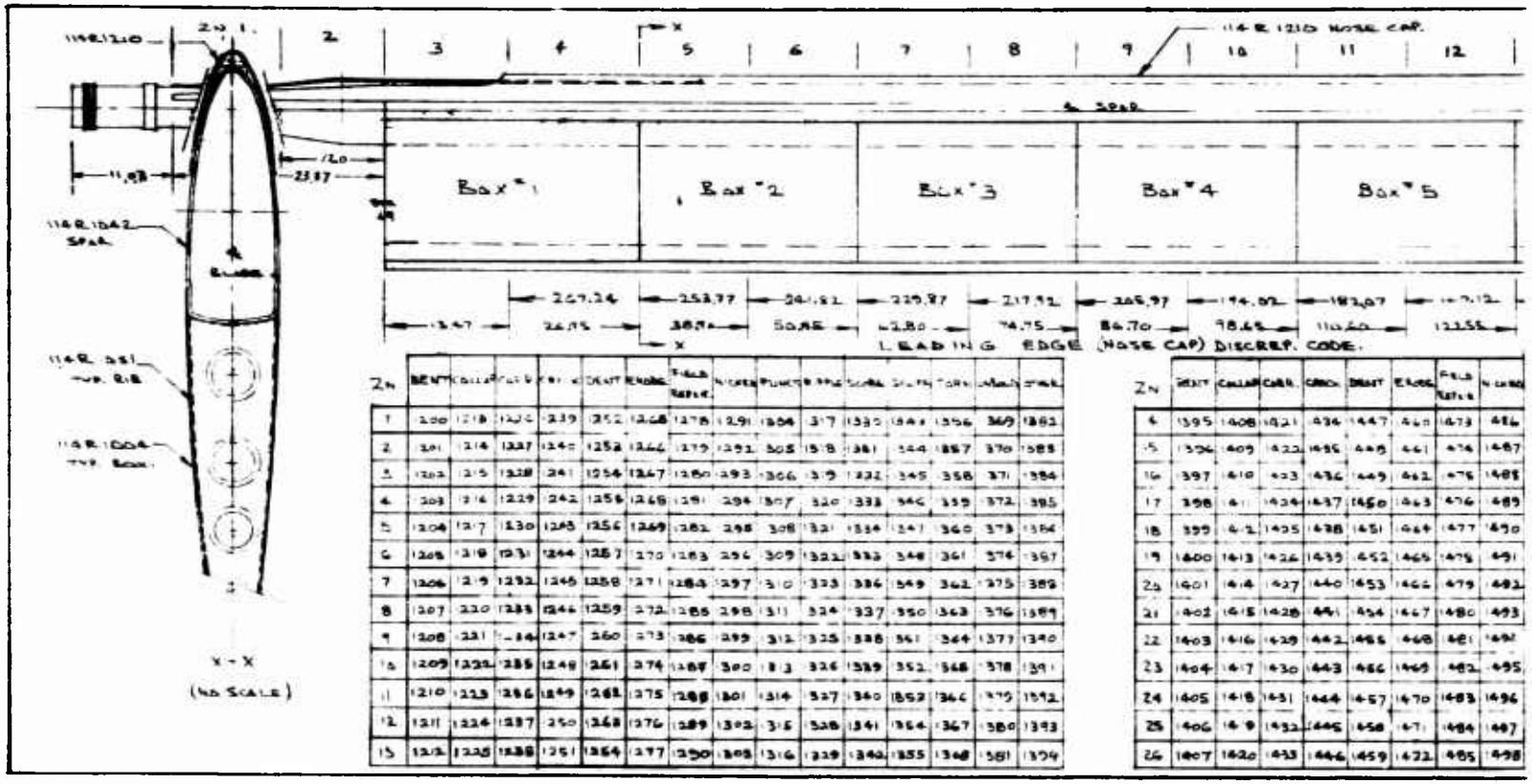


FIGURE 40. ALPHANUMERIC CODE - SHT. 9 - CH-47A.